FINAL

Technical Memorandum of the Baseline Human Health Risk Assessment Technical Approach for the Additional and Uncharacterized Sites Operable Unit

Crab Orchard National Wildlife Refuge NPL Site Marion, Illinois

Prepared for

U.S. Fish & Wildlife Service
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SECTION 1
INTRODUCTION AND BACKGROUND INFORMATION

1.1 INTRODUCTION

The primary goal of a baseline Human Health Risk Assessment (HHRA) is to provide an assessment of the potential health risks associated with a site in the absence of any remedial actions, considering both current land use, as well as any potential future uses of the property. Furthermore, the HHRA characterizes the nature of chemical releases from a site and evaluates potential pathways for exposure to human receptors. Specifically, the HHRA will address potential risks associated with contaminated soils, sediments, surface water and groundwater for those Additional and Uncharacterized Sites Operable Unit (AUS OU) sites identified in the Preliminary Assessment/Site Inspection (PA/SI) and the Administrative Order on Consent for the AUS OU as requiring further investigation in the Remedial Investigation (RI). The HHRA is ultimately used to estimate potential threats to public health due to chemical releases. Information on the chemical release data and potential risks are important factors in the evaluation of remedial alternatives. This Technical Memorandum (TM) provides a detailed overview of the technical approach to be used in the HHRA for the AUS OU of the Crab Orchard National Wildlife Refuge (Refuge).

The organization of this TM follows the structure presented in the Risk Assessment Guidance for Superfund (RAGS; USEPA, 1989) and consists of the following:

- Section 1: General site background information including a brief description of each site within the AUS OU that will be evaluated in the HHRA. Where possible, these descriptions include physical descriptions of the sites, site histories, current land use information, as well as other relevant site-specific information that can be used to support the contaminant assessment and exposure assessment sections of the HHRA. While much of this information is repetitive to what will be included in the RI Report, it will be included because the HHRA is frequently reviewed as a “stand-alone” document.

- Section 2: Identification of the primary guidance documents that will be used in preparation of the HHRA.

- Section 3: A data evaluation section that discusses how site data will be segregated by medium, depth, and location, the procedures that will be used in the HHRA for selecting the Chemicals of Potential Concern (COPCs), and the statistical methods that will be used to calculate exposure point concentrations.

- Section 4: An exposure assessment that identifies, on a site-specific basis, potentially complete exposure pathways, receptor populations, exposure routes, and exposure parameters to be used to quantify exposure and risk.

- Section 5: An additional list of references used throughout the document.

As required by USEPA Region 5, part of the HHRA deliverables will include the RAGS D standardized reporting tables (USEPA, 2001b) . Per the directions provided in the RAGS D guidance, these table will be provided to the agency for review as a series of interim deliverables. The first set of these tables (Table 0, Site Risk Assessment Identification Information; Table 1, Selection of Exposure Pathways; Table 4, Values Used for Daily Intake Calculations) are included in **Appendix B** of this Technical Memorandum.

1.2 SITE BACKGROUND INFORMATION

Thirty-one AUS OU sites will be evaluated in the HHRA, based on previous screening during the PA/SI, plus Area 3, the former Illinois Ordnance Plant (IOP) Finished Ammunition Area, will also be evaluated in the HHRA. Area 3 was not included in the PA/SI, but will be addressed in the RI for the AUS OU. These sites, shown in **Figure 1**, vary widely in geographic size and complexity of contaminant issues.

The two major site groups in the AUS OU, in terms of size and complexity, are the Area 2 sites and the Area 11/12 sites. The Area 2 sites (2B, 2D, 2F, 2P, and 2R) include about 550 acres of currently active, fenced industrial facilities that have been in operation, with brief breaks, since 1942. The six sites in Areas 11/12 (11A, 11H, 11N, 11P, 11S, and 12) include about 300 acres of former industrial facilities; the tenant leases covered over 600 acres, which included buffer zones. The Area 11/12 sites were used during World War II, and then by industrial tenants from 1956 to 1982. Decontamination for explosives only was done by industrial tenants in the 1970s and early 1980s, and the remaining buildings were razed by USFWS in the 1980s. All these sites have revealed significant contamination in almost all media sampled.

Intermediate in terms of size and complexity are other sites in numbered industrial areas which were part of the IOP facility and were used later by post-World War II industrial tenants. Parts of these areas which had high levels of industrial activity have already been remediated or are planned for remediation as parts of other operable units on the Refuge.[1] Thus, parts of Area 4

[1] The Army remediated a very small site in the southern part of Area 12, which is considered as part of the major site groups. The remediated site, COP-4, is part of the Explosives and Munitions Areas Operable Unit (EMMA OU). The extent of industrial activity in Area 12 extended well beyond the small site that was remediated. The remedy did not address significant areas of contamination at Area 12, as most of the remedies at the intermediate-size sites did.

East, Area 4 West, and Area 7 were remediated as part of the Metals Areas OU (MAOU); a large portion of Area 9 is part of the PCB OU remediation; and the northern portion of Area 8 is planned for remediation as part of the Miscellaneous Areas OU (MISCA OU). The remedies for these OUs have addressed much of the contamination in these areas. The remaining portions of Areas 4, 8, and 9 (those not included in other operable units) generally did not have as high a level of industrial activity as the sites in Areas 2 and 11/12. The other industrial areas discussed below (3, 6, 7, 10, and 13), which were not included in other OU remedies, also have not had as great a level of industrial activity.

At the other end of the spectrum are small sites, with little industrial history, and contamination that appears to be at lower levels and limited in extent. Examples of these sites are AUS-0065, AUS-0066, AUS-0067, AUS-0018, and AUS-0043.

Each of these 31 sites is summarized below. Each summary briefly describes the site, the operational history and waste characteristics, and major operators/lessees. The summaries in this section are grouped as follows:

- Area 2 sites: 2B, 2D, 2F, 2P, and 2R identified as AUS-0A2B, -0A2D, 0A2F, 0A2P, and 0A2R. Site 2R, a railroad spur near the manufacturing areas 2B, 2D, 2F and 2P, is included because of proximity.

- Area 11/12 sites: 11A, 11H, 11N, 11P, 11S, and 12, identified as AUS-A11A, -A11H, -A11N, -A11P, -A11S, and -0A12.

- Other sites in industrial areas: 4 East, 4 West, 6, 7, 8 South, 9, 10, and 13 identified as AUS-0A4E, -0A4W, -0A06, -0A07, -0A8S, -0A09, -0A10, and –0A13.

- Sites in the COC Area: AUS-0062, -0065, -0066, -0067, and -0069.

- Other small sites not in industrial areas: AUS-0001, -0002, -0018, -0043, -0060, -0061, and –106A.

1.2.1 Area 2 Sites

Area 2 is located on the east side of Wolf Creek Road, north of Crab Orchard Lake. During the IOP era (1942-1945), this area was used for loading boosters, detonators, fuses, and primers for the ordnance produced at the IOP. Boosters, detonators, fuses and primers are parts of the explosive train in a device such as a bomb or mine. The material that makes up the actual bursting charge in a bomb or mine, which was primarily TNT at the IOP, is relatively insensitive and is set off by a series of decreasingly sensitive, but increasingly powerful charges. The sequence in the explosive train is fuse/primer/detonator/booster. These IOP uses are the basis for the sub-area designations still in use today (Areas 2B, 2D, 2F, and 2P).

Area 2 has been leased by industrial tenants continuously since 1952 and is a current industrial facility. Only two major tenants have occupied this area: Universal Match Corporation (UMC) (later Crane/Unidynamics-Phoenix, now Crane Co.), and Olin/Primex/GDO&TS,[2] both manufacturers of munitions, propellants, and related products. Olin/Primex/GDO&TS has been the sole tenant in Area 2 since 1970.

Area 2 is currently fenced, and access is controlled by the tenant. Areas 2B, 2F, and 2D are connected by roadways and are serviced by a single main security entrance on Post Oak Road, at the north end of Area 2. Access to Area 2P is through a security entrance on Stringtown Road, at the south end of Area 2.

AUS-0A2B (Area 2B)

Site Description

Area 2B, the former IOP Booster Loading Line, is on the west side of Area 2. The IOP Booster Load Line consisted of 17 buildings. All the building numbers were prefixed with “B-2.” Later industrial tenants added and removed buildings. This fenced site covers about 125 acres.

Operational History and Waste Characteristics

Boosters produced at the IOP used tetryl (N-methyl-N,2,4,6-tetranitroaniline) for the explosive charge and they may also have contained some mercury fulminate. Tetryl was delivered from off site; processing on the booster load line included screening, blending, pressing, and loading.

Post-World War II industrial tenants used Area 2B for ordnance and pyrotechnic manufacturing. UMC began operating in Area 2B sometime after 1952. UMC used Area 2B for tetryl-pelleting operations, manufacturing gas generators and delayed fuses, and for loading large explosive devices. UMC also used this area for manufacturing and testing pyrotechnic devices including

[2] Olin Corporation (formerly Olin Mathieson Chemical Corp.) spun off its ordnance manufacturing division to Primex Technologies, Inc. (Primex) at the end of 1996. In January 2001, General Dynamics Corporation acquired Primex. Primex became a wholly owned subsidiary of General Dynamics and changed its name to General Dynamics Ordnance and Tactical Systems, Inc. (hereafter referred to as GDO&TS). Primex took over the Olin leases at the end of 1996. GDO&TS assumed the leases in January 2001.

explosive switches, igniters, detonators, flares, and atomic bomb burst simulators. UMC left the Refuge in 1963.

After UMC left, several former UMC employees formed Central Technologies, Inc. (CTI), which manufactured and tested pyrotechnic devices in Areas 2B for a short period. Little is known of their operation.

Olin/Primex/GDO&TS began leasing in Area 2B in 1963 and has been the only documented lessee in Area 2B since 1970. GDO&TS is the current tenant. Olin/Primex/GDO&TS has used Area 2B for manufacturing ammonium nitrate propellants, ammonium oxalate inhibitors, insulator mixes, and magnesium-teflon flares; for machining; testing gas generators; storing hazardous waste; and for quality assurance laboratory analysis. One building contained a trichlorethane vapor degreaser.

Statements by former employees of both UMC and Olin indicate that dumping of organic chemicals (solvents) onto the grounds around process buildings was common. It is likely that this type of activity was also prevalent during the IOP period. Solvents reportedly used and/or dumped by industrial tenants include methylene chloride, methyl ethyl ketone, acetone, trichloroethylene (TCE), and hexane. Documented Olin wastes include the following, among others: beryllium dust; salts of barium, cadmium, chromium, lead, mercury, selenium, and silver; trichloroethane; di-n-octyl phthalate; dimethyl phthalate; toluene di-isocyanate, spent halogenated solvents; and 2-nitrodiphenylamine.

During regular cleaning activities in some process buildings not containing sumps, water was used to hose down the building interiors. The wash water was then allowed to drain out the door onto the surrounding grounds and ditches.

Olin was known to have used the following chemicals at the Refuge, among others: boron, barium nitrate, chromic acid, mercury, copper sulfate, zinc oxide, chloroform, and several phthalates.

Both UMC and CTI reportedly maintained burn pads in Area 2B. Early industrial tenants at the Refuge used burning as a principal means of disposing of explosive and other industrial wastes.

AUS-0A2D (Area 2D)

Site Description

Area 2D, the IOP Detonator Loading Line, is located on the north side of Area 2. The original building complex consisted of 41 buildings. All the building numbers were prefixed with "D-1." Industrial tenants have removed some buildings and added many more. Building numbers now extend into the 90s. This fenced site covers about 150 acres.

Operational History and Waste Characteristics

Detonators produced at the IOP used lead azide, tetryl, and probably mercury fulminate as the explosive charge. Other materials used in production were antimony sulfide and potassium chlorate. Explosives were not manufactured at the IOP; they were shipped in and processed on the load lines.

Since World War II, ordnance and pyrotechnic manufacturers have used Area 2D for production. UMC leased Area 2D from 1953 to 1963. UMC reportedly began with research and development of primary and secondary explosives, pyrotechnic devices, and propellants in Area 2D. Originally UMC's production work at the Refuge consisted mainly of pyrotechnic devices, initiators (fuse trains), large explosive devices, smoke markers, and photoflash shells. UMC reportedly used lead styphnate and lead azide in their operations.

Olin/Primex/GDO&TS has operated in Area 2D from 1964 to the present. Olin began the bulk of its solid propellant operations (SPO) in Area 2D in 1964. This included gas generators, jet starters (starter cartridges), tank pressurizers, missile guidance control products, and aircraft emergency evacuation slide inflation devices. Solid propellants are manufactured by mixing the propellant components together in a mixer either dry or with a solvent. Powdered lead stearate was reportedly used in the manufacture of gas generators in Area 2D, as was TCE.

Other Olin/Primex/GDO&TS Area 2D products include the Light Antitank Weapon (LAW) rocket, 20mm fuses, boosters, and ammunition ignition mixes. Olin/Primex also used several building in Area 2D for storage of explosive/hazardous waste and used some buildings as explosive scrap pick-up points.

Refer to the discussion under AUS-0A2B above for a description of the dumping of organic chemicals, industrial tenant cleaning activities, chemicals used, waste products, and waste burning.

Both UMC and Olin reportedly maintained burn pads in Area 2D.

AUS-0A2F (Area 2F)

Site Description

Area 2F, the IOP Fuse Loading Line, is located east of Area 2B and south of Area 2D. The original Area 2F building complex consisted of 14 buildings, all prefixed with "F-2." Industrial tenants have removed some buildings and added others. This fenced site covers about 125 acres.

Operational History and Waste Characteristics

The IOP Fuse Loading Line was used for manufacturing delays and fuses which included the preparation and loading of black powder, lead azide, antimony sulfide, potassium chlorate, and tetryl.

UMC leased Area 2F from 1959 to 1961. There is little information about UMC's activities in Area 2F.

Olin/Primex/GDO&TS has operated in Area 2F from 1970 to the present. Olin/Primex/GDO&TS manufactured artillery projectiles in Area 2F. Olin also had a metal fabrication operation in Area 2F that used cutting oils and degreasers, including TCE and/or methylene chloride. This area has also been used as a storage facility for components and finished products, as well as for fuels and oxidizers such as magnesium, boron, perchlorates, nitrates, and peroxides. The area has also reportedly been used for manufacturing propellant systems and gas generators.

Refer to the discussion under AUS-0A2B above for a description of the dumping of organic chemicals, industrial tenant cleaning activities, chemicals used, waste products, and waste burning.

A large area that has been used as a dumping ground was observed during the site reconnaissance, at the north end of Area 2F. Dumped materials observed in the area during site work in 2000 include soil, trees, construction debris and three boilers.

AUS-0A2P (Area 2P)

Site Description

Area 2P, the IOP Artillery Primer Loading Line, is on the south side of Area 2, and originally consisted of 14 buildings, all designated with “P-1.” Since the end of World War II, some buildings have been removed and others added by industrial tenants. This fenced site covers about 150 acres.

Operational History and Waste Characteristics

Primers that were loaded at the IOP Primer Loading Line were constructed of inert materials such as brass, onion skin paper, percussion cup and beeswax. They also contained ignitable components such as percussion compounds and black powder, which is made up of potassium nitrate, sulfur, and charcoal.

The only known industrial tenant in Area 2P is Olin/Primex/GDO&TS, which has leased the area from 1957 to the present. Olin’s use of Area 2P began with research and development (R&D) of solid propellants, and some production of solid propellants. A small part of Olin’s work in Area 2P was developing ball powder propellant that included materials such as nitroglycerin, dioctyl phthalate, and other plasticizers. Initially, a larger part of Olin’s work in Area 2P involved gas generators that included the use of ammonium nitrate with a plastic/rubber base.

Olin’s solid propellant R&D activities involved the small scale mixing of solid propellants and their subsequent testing. During the 1970s, Olin began R&D for their ammunition product lines in Area 2P.

Degreasers and solvents were used in solid propellant production in Area 2P. Olin used some of the buildings in this area for storage of solvents, plasticizers, propellants, ammunition, incendiary mixes, and for PCB transformers. Olin also used some of the buildings for ballistic testing, black powder screening and pelleting, gas generator testing, and for machine shop activities such as welding, lathing, and degreasing.

Olin also generated the following explosive scrap which was stored at pick up points in Area 2P: J-66 type ammonium perchlorate, ammonium nitrate rubber, perchlorate propellant with iron oxide, composite double base propellant containing aluminum and ammonium perchlorate, and ethyl acetate with scrap propellant. Primex used some of the buildings as 90-day hazardous waste accumulation areas.

AUS-0A2R (Area 2R)

Site Description

Area 2R is a railroad spur that was constructed as part of the IOP and has been used by later industrial tenants. The site, which covers about 30 acres, is located just northeast of the rest of Area 2 and was considered a part of Area 2 in the PA/SI report.

The site currently consists of two storage areas, a railroad spur and a loading dock. There were originally two rail spurs and one main line.

Operational History and Waste Characteristics

The USFWS operated the railroads on the Refuge from 1947 to 1976. It is assumed that any of the tenants in Area 2 may have used the rail lines and loading docks in Area 2R. The area is now used by GDO&TS, the current Area 2 tenant.

Open storage of materials, an excavation with probable liquid, and a probable horizontal tank were observed on the 1943 aerial photograph. A possible disposal area was noted on the 1980 aerial photograph.

1.2.2 Areas 11/12 Sites

Areas 11 and 12, located south of Crab Orchard Lake, are addressed together because they were part of a single, large post-World War II industrial facility. At the north end of this now contiguous area is the site of the IOP Group II Load Line, which is in Area 11. At the south end is the site of the IOP Ammonium Nitrate Plant, which is in Area 12. The current Areas 11/12 include these two IOP features plus about 100 to 200 acres of Refuge land between them that was developed by post-Word War II industrial tenants. The enlarged industrial complex, including buffer zones, covered over 600 acres. Access was limited to tenant employees.

Because of its size and the variety of past industrial activities, the PA/SI evaluated Area 11 as five separate sites. The boundaries of these five sites are based on industrial use by Olin and Commercial Solvents Corporation (CSC), the major tenants, as follows:

- Area 11A—acid and ammonium nitrate manufacturing (Site AUS-A11A).
- Area 11H—high explosives manufacturing (Site AUS-A11H).
- Area 11N—nitroglycerin manufacturing (Site AUS-A11N).

- Area 11P—propellant manufacturing (Olin), explosive cap manufacturing (CSC) (Site AUS-A11P).
- Area 11S—support area for explosives manufacturing (Site AUS-A11S).

Beginning in 1956, Areas 11 and 12 were leased by Olin and used primarily for manufacturing industrial (non-military) explosives. Olin built an acid and ammonium nitrate plant using some of the IOP Group II Load Line structures. Olin also constructed and operated a nitroglycerin plant, dynamite mix houses, a burn area, and ponds for storage of millions of pounds of explosives. These features were built in previously undeveloped parts of the Refuge between the original Group II Load Line and the Ammonium Nitrate Plant.

Olin sold its industrial explosives business to CSC in 1963 and CSC moved into Areas 11/12 in 1964. CSC and its successors leased this area from 1964 through 1982. Part of the sale to CSC included an RDX manufacturing operation and an explosive cap manufacturing operation, both of which were located at Olin facilities off the Refuge and moved by CSC to Areas 11/12. Olin also operated a pilot propellant plant in Area 11 which was not included in the sale. Olin moved the propellant operation to Area 2 prior to the sale.

Trojan Powder Company, a CSC division, operated the Area 11/12 facility after the Olin sale. Manufacturing was phased out beginning in 1968, and ended completely sometime before 1976. Trojan did some explosive decontamination in 1971 and 1972, but was still storing explosives at the site in 1977, when its successor, IMC Chemical Group (IMC), petitioned the Illinois Pollution Control Board for a variance from the regulations that prohibited open burning because such burning was necessary for further decontamination of the buildings in Areas 11 and 12. Three variances were granted during 1977 and 1978, for building decontamination and destruction of unusable explosives. After IMC removed the remaining usable explosives and completed the explosive decontamination, they left the site in 1982. Mallinckrodt, Inc. is the corporate successor to CSC/IMC. The purpose of the CSC/IMC decontamination was to eliminate explosive hazards at the site. The work did not address chemical contamination. The remaining buildings in the area were demolished by the USFWS in the late 1980s and early 1990s.

AUS-A11A (Area 11 Acid and Ammonium Nitrate Area)

Site Description and Operational History and Waste Characteristics

Area 11A, the acid and ammonium nitrate manufacturing area, is located in the north-central portion of Area 11 between Areas 11P and 11S. This area was part of the IOP Group II Load Line and was used mostly for TNT and ammonium nitrate storage and screening.

Both Olin and CSC used this area as an acid and ammonium nitrate production facility, beginning with Olin in 1957. Nitric and possibly sulfuric acid were produced. Both acids were stored in this area. CSC used the buildings and other facilities as Olin did, with minor changes. CSC/IMC ended production in Area 11A in 1969.

AUS-A11H (Area 11 High Explosives Area)

Site Description

Site AUS-A11H, the High Explosives Area, is located in the western portion of Area 11 just south of Area 11P. It was used by industrial tenants for manufacturing high explosives from the 1950s to the 1970s. During World War II, the northern section of Site AUS-A11H was part of the IOP Group II Load Line.

Operational History and Waste Characteristics

Area 11H was used by the SWDC/War Department during IOP operations as a part of the Melt Loading Line and included two change houses and a melt loading building.

Olin constructed the High Explosives Manufacturing Area, or Dynamite Area, on the property between the IOP Group II Load Line and the IOP Ammonium Nitrate Plant. Note that the term "dynamite" as used here is a generic term for industrial blasting explosives. It appears that Olin produced nitroglycerin dynamite in this area, as well as ammonium nitrate fuel oil explosives (ANFO), and water gel and slurry explosives which are the common explosives used in the mining industry.

The major constituents of nitroglycerin dynamite are nitroglycerin and dope, which is a general term for the porous combustible material that is combined with nitroglycerin to form dynamite. Some other raw materials used in production were ammonium nitrate, nitrocellulose, nitrocotton, ethyl centralite, and dimethyl sebacate (also known as dimethyl ester).

Water gels and slurry explosives consist of ammonium nitrate with or without other oxidizing agents, sensitizers, fuels, and gelatin forming compounds. Materials that are commonly used as additives in these explosives, and that Olin was known to have used in Area 11H, include TNT and smokeless powder. Other common additives that might have been used are pentolite, methylamine nitrate, potassium dichromate and PETN.

CSC and its successors operated the High Explosives Area from 1964 until they phased out production between 1968 and 1971. CSC most often used the same buildings for the same purposes as Olin; however, CSC used Building 22 for their Torpex operation. Torpex is composed of RDX, TNT, aluminum powder and wax.

AUS-A11N (Area 11 Nitroglycerin Area)

Site Description

Area 11N, the Nitroglycerin Area, is located in the eastern portion of Area 11, south of Area 11S and east of Area 11H. Post-World War II industrial tenants used this area for manufacturing nitroglycerin, from the 1950s to the 1970s. During World War II, a small portion of the northern section of Site AUS-A11N was within the IOP Group II Load Line and was used as a parking area, with no buildings.

Operational History and Waste Characteristics

Olin began manufacturing nitroglycerin in late 1957, at the same time it began acid and ammonium nitrate production in Area 11A. Olin produced nitroglycerin by the Biazzi process, which used concentrated nitric and sulfuric acid, pure glycerin or ethylene glycol, and soda ash. The wastewater from the nitroglycerin manufacturing was probably discharged to the East Holding Pond just north of the Nitroglycerin Area. This wastewater probably contained soluble materials like ammonium nitrate, sodium nitrate, acid, and traces of nitroglycerin.

After they acquired it from Olin, CSC probably continued to operate the nitroglycerin manufacturing facility the same way as Olin had.

There were eight possible burning trenches located in AUS-A11N that were identified in historical aerial photographs. The AUS OU site reconnaissance identified two buried railroad tank cars in Area 11N. Buried railroad tank cars are known to have been used at other industrial facilities for liquid waste or fuel storage.

AUS-A11P (Area 11 Pilot Propellant Plant/Cap Production Area)

Site Description

Site AUS-A11P, the former Area 11 Pilot Propellant Plant/Cap Production Area, is located in the northwestern portion of Area 11, west of Area 11A and north of Area 11H. From the 1950s to the 1970s, industrial tenants used this area for propellant/explosives manufacturing. During World War II, this site was part of the IOP Group II Load Line.

Operational History and Waste Characteristics

Several buildings within AUS-A11P were originally a part of the IOP Group II Load Line which SWDC/War Department operated during World War II. Shells, anti-tank mines and 500-pound (lb) bombs were loaded with TNT on this line.

Olin began occupying Area 11 in 1956. They initially used this area as a Pilot Propellant Plant for research and development of propellants, and may have later used this area for the manufacture of jet starter cartridges or jet engine starters. Solid propellant used at this plant was composed of ammonium nitrate, synthetic rubber, carbon black, and ammonium oxalate. The propellants contained ammonium perchlorate, magnesium, aluminum, and a plastic binder.

Some of the chemical constituents of gas generators produced by Olin were perchlorates, ammonium nitrate, hexane and various plasticizers. Olin also tested experimental explosive devices in a building in this area. Olin jet engine starters were made using nitroglycerin and ball powder. Ammonium nitrate, nitrocellulose and a plasticizer – dioctyl phthalate – were also used in the gas generators for the jet engine starters.

After Olin sold a portion of its business to CSC in 1964, CSC leased the former Olin facility and used it for the manufacture of Big Inch Caps, which were listed as “Blasting Caps” “for detonators” in the Olin/CSC agreement. The caps were ½-inch in diameter and 1-inch long. They were used with a cord fuse and contained a combination of lead azide and lead styphnate. According to CSC/IMC records, RDX, lead azide and lead styphnate were the explosive contaminants of concern in the buildings used for Big Inch Cap production. CSC/IMC ended production sometime around 1971.

AUS-A11S (Area 11 Support Area)

Site Description

Site AUS-A11S, the Support Area, is located in the northeastern portion of Area 11, east of Area 11A and north of Area 11N. During World War II, the area was part of the IOP Group II Load Line. Site AUS-A11S was used by industrial tenants from 1946 to the 1980s, primarily as a support area for the high explosives manufacturing.

Operational History and Waste Characteristics

SWDC/War Department operated the IOP Group II Load Line during World War II. The area occupied by Site AUS-A11S was on the front end of the load line, where shells were delivered, cleaned and painted. Silas Mason Company, a War Department contractor who operated the IOP Ammonium Nitrate Plant in Area 12 from 1946 to 1950, also occupied two buildings in Area 11 as warehouses from 1946 to 1948.

Post-IOP industrial tenants included Hoosier Cardinal Corporation (Hoosier) who leased property in Area 11 from 1948 to 1956. Hoosier manufactured and finished decorative equipment and emblems for stoves, refrigerators and automobiles.

During Olin's tenure from 1956 to 1964, most of the buildings in the Support Area were former IOP buildings. Olin used the buildings in this area for a boiler house, laboratory, a component magazine, a carpenter and machine shop, a garage, a welding shop, and oil storage.

CSC/IMC apparently used most of the buildings in Site AUS-A11S for the same purposes as Olin.

AUS-0A12 (Area 12 Former Ammonium Nitrate Plant)

Site Description

Area 12 was the former IOP Ammonium Nitrate Plant. It is located south of Area 11, and is accessible by way of Area 11 roadways. It originally consisted of 12 buildings designated with the prefix "ANP-1.

The area has been unoccupied since 1982, and all buildings have been removed.

Operational History and Waste Characteristics

SWDC/War Department used Area 12 for ammonium nitrate production during World War II. The IOP was a "melt-pour" facility. Explosives that were produced elsewhere were melted and poured into various ordnance shells. TNT was the preferred explosive, but because of a TNT shortage, many ordnance plants, including the IOP, were designed and built to use amatol, a mixture of TNT and ammonium nitrate. Unlike TNT, ammonium nitrate was produced at the plant. When the TNT shortage ended in 1943, TNT alone was used for the main ordnance explosive, and ammonium nitrate production stopped.

The process of producing ammonium nitrate included passing ammonia gas through the nitric acid creating a solution that was then stirred to facilitate evaporation of the product.

Silas Mason, under contract with the War Department, manufactured fertilizer-grade ammonium nitrate sometime between 1946 and 1950. In 1950, fertilizer production ended, and the Army transferred control and jurisdiction of the facility to the United States Department of Interior (USDOI).

Post-IOP industrial tenants included UMC, who tested photo flash signals in this area for approximately six months during 1955. Barium nitrate and potassium perchlorate were waste products from the manufacture of photo flash signals.

Olin leased this area from January 1956 through April 1964 for storage, burning, and explosives manufacturing. Olin originally manufactured ammonium nitrate in Area 12 until its ammonium nitrate facility in Area 11 was completed. It is likely that Olin also used Area 12 to manufacture Olinite 7, which was a form of dynamite made with ammonium nitrate and diesel fuel.

In 1960, Olin constructed and filled eight powder storage ponds in the area between the IOP Group II Load Line and the Ammonium Nitrate Plant. The ponds were excavated, lined with a black plastic, filled with powder and then filled with water. Olin stored flashless, non-hydroscopic powder (FNH) in these ponds.

Olin reported that open burning began in this area in 1956 and continued until 1964, and they estimated that 4,000,000 lbs of explosives, pyrotechnics and propellants were burned in these burning grounds from 1956 through 1964. They also estimated that approximately 40,000 lbs of primarily metal oxides remained at the burning grounds.

CSC occupied Area 12 from April 1964 through 1982. CSC (and its successors) used this area for storage and for RDX production. Burning grounds were still present on the western side of the property during CSC’s tenure, and presumably were used by CSC.

1.2.3 Other Sites in Designated Refuge Industrial Areas

Fourteen numbered industrial areas have been designated on the Refuge (Areas 1 through 14). These designations began with the various IOP building complexes but, as discussed above, some of the numbered areas have grown beyond the boundaries of the original IOP building complexes.

In addition to Areas 2 and 11/12 discussed above, several of the other numbered industrial areas are AUS OU sites. These are Area 3, Area 4 (divided into Area 4 East and Area 4 West), Area 6, Area 7, Area 8 South, Area 9, Area 10, and Area 13.

AUS-0A03 (Area 3)

Area 3 was the IOP Finished Ammunition – Group I Area (FAM) and the buildings have since been leased to industrial tenants. Area 3 was not included in the PA/SI, but will be addressed in the RI for the AUS OU.

AUS-0A4E (Area 4 East)

Site Description

Area 4, the IOP Shop Area, is north of Crab Orchard Lake on both sides of Highway 148. The PA/SI divided Area 4 into two separate sites: Area 4 East, which includes all of the Area 4 buildings on the east side of Highway 148, and Area 4 West, which includes all Area 4 buildings on the west side of Highway 148.

Area 4 East was originally built as an automotive shop to support IOP operations. Only two of the six original buildings remain. Since World War II, the area has been used by various tenants for purposes such as manufacturing and storage. The site covers about 60 acres.

Operational History and Waste Characteristics

During World War II, this area was used for maintenance of the IOP truck pool and heavy equipment. All automotive shop buildings begin with the designation “S-4”; they include a wash and grease house, a gas station, a garage, and buildings for the storage of oil and auto parts. Another building, S-3-4, was used to pump fuel to the West Shop Area.

Tenant uses of the buildings varied from manufacturing wrought iron items, latex rolls, and crates and cartons. Area 4 East was also used for refurbishing mining equipment and likely for vehicle maintenance, and as a service garage. The current tenant in this area is Ensign Bickford Industries.

AUS-0A4W (Area 4 West)

Site Description

Area 4 West, an approximately 80-acre site on the west side of Highway 148, originally housed buildings that supported IOP infrastructure and operation. All of the building designations start with the prefixes "S-1," "S-2" or "S-3; " and the buildings are arranged in three corresponding north-south oriented rows. Some buildings are no longer on site.

Operational History and Waste Characteristics

IOP buildings included a laundry, a locomotive repair building, a tool and gage shop, a laboratory, a machine shop, a piping and plumbing shop, a boiler house, and a light equipment repair building.

After the end of World War II, several of the buildings were leased by businesses including furniture, transformer, and coder cartridge manufacturers; printers; lumber suppliers; and publishers. There were also two plating operations. Under the direction of the Illinois Environmental Protection Agency, one of these tenants (Supreme Plating) cleaned and emptied an underground tank that contained liquid waste from its operation. Part of this area was also remediated under the Metals Areas Operable Unit.

GDO&TS is the major current tenant in Area 4 West.

AUS-0A06 (Area 6)

Site Description

Area 6 is the former IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area. This approximately 550-acre site is located south of Old Highway 13, in the eastern part of the Refuge. Area 6 consists of 79 explosive storage igloos in 7 rows. All of the igloos numbers are prefixed with "HE" (high explosives).

Operational History and Waste Characteristics

During the IOP era from 1942 through 1945, all of the igloos in this area were used for storage of high explosives. Tenants have since used the igloos mostly for storage of propellants and explosives. Some tenants have also stored pesticides, gun powder, fireworks, and fertilizers.

One of the current tenants, Dooley Brothers, Inc., indicated they buried explosive materials next to Igloos HE-7-11 and HE-7-12 on two occasions.

GDO&TS and Ensign Bickford Industries, Inc. are the two major current tenants in Area 6.

AUS-0A07 (Area 7)

Site Description

Area 7, the IOP Inert Storage Area, is located just south of the east end of Crab Orchard Lake. It was used for warehousing metal parts and other inert materials used in ordnance production. The site also incorporates the former Site AUS-0021, the Area 7 Fire Station.

The original building complex consisted of 6 rows of buildings (6 to 7 buildings per row) each of which were 51 feet (ft) wide by 200 ft long. All building numbers were prefixed with “IN” (for Inert Storage). The site covers about 100 acres.

Operational History and Waste Characteristics

During the IOP era, all but two of the buildings in Area 7 were used as warehouses for inert storage.

A succession of tenants have since leased the buildings, mostly for storage, but a few were used for manufacturing and maintenance work. Great Lakes Terminal and Transport Company had a pesticide storage operation and Olin had a short-lived metal fabrication operation. Significant pesticide contamination has been detected in the soils near the former pesticide storage area. Pesticides have also been detected in fish in Crab Orchard Lake, and may or may not be related to the Area 7 pesticides. The pond which apparently received discharge from Olin’s operation was remediated as part of the Metals Area OU, but the site of the operation itself has not yet been investigated.

AUS-0A8S (Area 8 South)

Site Description

Site AUS-0A8S is south of Crab Orchard Lake and includes the southern part of the former IOP Group III Load Line. The load line originally included 29 buildings, which were prefixed with “III-1.” The site includes about 150 acres.

The only remaining buildings from the Group III Load Line are those from the northern portion of the former load line. None of the buildings in the site designated as AUS-0A8S are still on site.

Operational History and Waste Characteristics

Load Line III was an IOP melt-pour operation for 500 pound bombs. TNT, which was sometimes blended with ammonium nitrate, was brought from off-site, melted, and poured into the bomb casings.

Products manufactured by post-World War II tenants included fiberglass canoes, propellants, pyrotechnics, and ground explosive powder. After a 1981 fire, the entire site was razed and buried. No industrial activity has taken place at Area 8 South since that time.

Olin occupied several of the former IOP buildings in Area 8 South from 1959 through the early 1960s for storage of ammonium nitrate fertilizer. Lease information indicates that Olin occupied the entire southern portion of Area 8 from 1960 through 1962.

Petrof Trading Company (Petrof) occupied two Area 8 buildings in the late 1960s. Petrof's operation in Area 8 involved grinding explosive powder. After Petrof left the site, black powder that he had left behind was buried by the USFWS and the burial area was fenced off and marked.

CTI leased the south end of Area 8 from June 1969 to November 1970. CTI produced pyrotechnic devices for the military and their major product was the Mark II ground burst simulator. They also produced cannon net traps and parts for rocket separators.

American Fiber-Lite, Incorporated (AFL), leased this area from 1973 to 1981, when fire destroyed the facility. AFL manufactured fiberglass products, primarily canoes. A former employee reported that AFL used organic solvents, such as toluene, for cleanup operations.

AUS-0A09 (Area 9)

Site Description

Area 9 was the IOP Group I Load Line and is located south of Crab Orchard Lake and east of Highway 148.

The Group I Load Line originally consisted of the 38 buildings. All the building numbers are prefixed with "I-1."Later industrial tenants have added many buildings and building numbers now extend into the 100s.

In 1996 and 1997, a large area in and near Area 9 was remediated as a part of the PCB OU. Site AUS-0A09 includes any part of Area 9 that requires further investigation and is not already part of the PCB OU. Site AUS-0A09 includes about 100 acres.

Operational History and Waste Characteristics

During World War II, TNT was screened, melted, and loaded on this artillery and bomb loading line.

There were two major tenants and several minor ones in Area 9. Sangamo Electric Company, later Sangamo Weston, Inc. (Sangamo), now Schlumberger Industries, Inc., was the first major tenant, and contamination from its operations is the focus of the PCB OU remediation. Olin and its successors have been the other major tenant.

From 1946 to 1962, Sangamo leased the site and manufactured various kinds of capacitors as well as transducers and delay line equalizers. Sangamo used lead to coat small parts, such as electrical connections. Sangamo also used degreasers and other chemicals in their manufacturing processes, such as acids, acetone, ethylene glycol, epoxy resins, silver, ammonia, trichloroethylene, perchloroethylene (PCE), and liquid Aroclor 1254 and 1242.

Olin/Primex/GDO&TS have leased buildings in Area 9 from 1967 to the present, for several different activities, including pyrotechnic operations, which included manufacturing magnesium flares and illumination flares; as well as medium caliber ammunition production.

See the discussion under the AUS-0A2B summary for known chemicals used and waste products generated by Olin and its successors.

AUS-0A10 (Area 10)

Site Description

Area 10, the former IOP Fuse and Booster Storage Magazine (FBM) area, is located south of Crab Orchard Lake, on the north side of Ogden Road. Area 10 was a group of 16 storage magazines for components of ordnance produced on the load lines. The site covers about 40 acres. The FBM area was in the shape of a polygon, and the storage magazines were arranged in four rows. All of the magazine numbers started with the prefix "FBM." By 1965, all of the magazines had been removed.

Operational History and Waste Characteristics

During World War II, fuses and boosters stored in Area 10 were transported to the IOP Load Lines, where anti-tank mines, bombs and artillery were being produced.

In 1949, USFWS used three of the magazines for grain storage. Sangamo, the only documented tenant in Area 10, leased two magazines from 1949 to at least 1951.

Although it had no leases in Area 10, Olin constructed and used large pits in this area for the incineration of ignitable wastes from its production operations. John Miller, a former Olin manager and chemist, indicated that Olin moved from one burning ground to another as they outgrew the previous burn areas, and that all of Olin's manufacturing operations on the Refuge used a single burn area at the same time. Olin documents indicate that their burning grounds were moved from Area 12 to Area 2D in 1965, from Area 2D to Area 9 in 1967 and from Area 9 to Area 10 in 1968. The Area 10 burn area was not available to other industrial tenants. It was in operation until open burning was banned at the Refuge in 1970.

Scrap explosive wastes that Olin burned at Area 10 consisted of propellant, illumination scrap mix, igniter scrap, laboratory waste pyrotechnic materials, and other explosives and explosive contaminated materials. Oil was added to explosive material to cushion and dampen the material to prevent explosions prior to burning. Scrap was collected at workstations or scrap areas and taken to Area 10 where it was dumped into the burn pits and topped with small quantities of ignitable powders.

Olin has estimated that 120,000 lbs of waste were burned in this area and that about 1,000 lbs of residue remained, consisting mainly of metal oxides. Olin reported that the soils in the vicinity of this burning ground possibly contained lead contamination, and also that fuel oil, acetone, lupersol (methyl ethyl ketone peroxide) and other chemicals would have been present in these pits.

In 1970, when open burning was banned, the pits were covered. Since that time the site has been used by local law enforcement personnel for small arms practice.

AUS-0A13 (Area 13)

Site Description

Area 13, IOP Finished Ammunition Igloos (FAI) Area, is west of Areas 10 and 11, and south of Crab Orchard Lake. The site originally included 88 igloos, and covers about 500 acres.

Operational History and Waste Characteristics

These finished ammunition storage igloos were constructed and operated by SWDC/War Department as part of the IOP. The igloos have been used by various post-war tenants to store raw materials and products.

Olin began leasing igloos in the southern half of Area 13 in 1956. It continued to lease igloos in Area 13, including some in the northern half, until Primex and then GDO&TS took over the Olin leases.

Reportedly, Olin stored and detonated (tested) nitroglycerin in Area 13. Also, Olin reportedly burned dynamite on the road in Area 13, in front of the igloos, using straw and diesel fuel.

Early lease and corporate information is incomplete, but it appears that CSC took over some of Olin's igloos in the northern portion of Area 13 when it purchased a portion of the Olin business on the Refuge in 1963. CSC later changed its name to International Minerals and Chemical Corporation (IMC). IMC sold a portion of its explosives business to Trojan Corporation in 1982. Trojan was acquired by Ensign Bickford Industries in 1986. For a time, Trojan leased the igloos in the southern portion of Area 13 in its own name; Ensign Bickford later took over the leases.

GDO&TS and Ensign Bickford currently lease all the igloos in Area 13. These igloos, in the southern and northern half of the area, respectively, have been used historically for propellant and explosives storage.

1.2.4 COC Area Sites

Five AUS OU sites are located in the area around the Crab Orchard Cemetery, (the COC Area), south of Crab Orchard Lake. After the end of World War II, the War Department used parts of this area to destroy surplus land mines and other ordnance products. There have been no industrial tenants in the COC Area. Several EMMA OU sites were located in this area. One has been remediated for chemical contamination and others have been remediated for ordnance only.

AUS-0062

According to the USFWS, AUS-0062 is a former landfill that was closed by the Refuge in 1974. The site covers about 2 acres. No activity was observed on aerial photographs of this area until 1971, when the site appeared to be a roadside clearing and fill operation. By 1980, the site appeared to be inactive

AUS-0065

AUS-0065 is an approximately one half-acre site in the COC area with building foundations and debris. Concrete foundations, soil mounds, depressions, and a brick structure resembling a well are currently visible on site. There have been no known industrial lessees of this property.

AUS-0066

AUS-0066 is a small wooded site in the COC area, covering about three quarters of an acre. AUS-0066 was originally described as “berm with red brick rubble” with a “Danger Contaminated Area” sign to the west. It was also COC-14 of the EMMA OU and was one of the COC sites investigated by the Army only for unexploded ordnance (UXO). In 1997, the Army conducted an ordnance and explosive waste (OEW) investigation at this site. A total of 20 magnetic anomalies were identified; all twenty were identified as ordnance scrap.

AUS-0067

AUS-0067 is an approximately one fourth-acre site located west of Wolf Creek Road and north of the COC Area Road. It was included in the AUS OU primarily because of suspect fencing and signage. AUS-0067 was originally described as “fence with contaminated area (sign) northwest of COC-6.” A collapsed foundation, a cistern, some construction debris and some soil mounds were observed during the site visit.

AUS-0069

AUS-0069 is adjacent to Crab Orchard Lake and partially coincides with EMMA OU Site COC-15, one of the COC sites for which no chemical analyses were performed as part of the EMMA OU RI. AUS-0069 was a dump site used during the IOP era. The site covers roughly 15 acres, and may extend into Crab Orchard Lake. Elevated levels of cadmium were detected in lake sediments during the sampling for the Lake Monitoring OU.[3]

The 1943 aerial photographs, taken during the IOP era, showed deposits of probable debris and large numbers of crated materials in this area, along with a looping access road. By 1951, there was still some ground scarring and mounded debris present on site, however it appears that activity in this area had been terminated.

During the site visit, rusted drums and other debris were observed. Most of the debris is located in a stand of trees along the lakeshore and some of the debris is in Crab Orchard Lake.

1.2.5 Other Small Sites

AUS-0001 (Fire and Police Headquarters)

This site is located west of Wolf Creek Road and south of Old Highway 13. No buildings remain on this site, which covers about 1.5 acres. The facility was originally constructed and operated by SWDC/War Department as a part of the IOP. The main building was razed sometime between 1971 and 1980. The Crab Orchard Sportsmen's Association used this building as their club headquarters.

AUS-0002 (Wastewater Treatment Plant, WWTP)

This site, about 1.5 acres in size, is south of Old Highway 13 and west of Wolf Creek Road. This IOP WWTP was originally constructed and operated by SWDC/War Department, apparently as a temporary facility to serve the Administrative Area of the IOP. Use of the plant was probably discontinued when the main wastewater treatment plant came on line in 1943.

The WWTP consisted of a blockhouse with four treatment pits and an assumed underground sewer line to the west emptying into two small lagoons. The blockhouse and the four treatment pits were razed sometime between 1980 and 1993. The lagoons are still on site. No industrial lessees were identified for this plant. According to the historical aerial photograph interpretations, this plant appears to have been abandoned sometime between 1943 and 1951.

[3] U.S. Fish and Wildlife Service, 2001. Final Preliminary Screening Analysis Report, Lake Monitoring Operable Unit, Crab Orchard National Wildlife Refuge Superfund Site, Marion, Illinois (Williamson County). *Prepared by URS Corporation*.

AUS-0018 (Railroad Classification Yard)

This site is located at the southeast corner of the intersection of Old Highway 13 and Route 148. It includes about 7 acres. Based on IOP drawings, there were numerous sets of railroad tracks and four buildings, all prefixed with "Y-1." All the tracks and buildings have been removed. This train-sorting facility was originally constructed and operated by SWDC/War Department as a part of the IOP and had a 200-car capacity. Larger post-World War II tenants in this area included Olin and Trojan/U.S. Powder/Commercial Solvents Corporation.

AUS-0043 (Areas 11 and 12 Fire Station)

This site, which covers about one half acre, is located south of Crab Orchard Lake and northwest of Areas 11 and 12. There are no remaining buildings on site. This fire station was operated by SWDC/War Department as a part of the IOP, and serviced IOP facilities in its area. No industrial lessees were identified for this site.

AUS-0060 (Fulminate Storage Igloos)

Site AUS-0060 is the location of the IOP Fulminate Storage Igloos, Area 14. The site is located north of Crab Orchard Lake and west of Area 2. It covers about 6 acres. Because of the relatively small size of the site and the fact that the original AUS OU designation as Site 60 included the entire area, the original designation was retained, rather than renaming it as Area 14. IOP used this site for storing lead azide and mercury fulminate, which are explosive components of detonators. There were five structures in this area: two azide storage vaults, two fulminate storage vaults and a guard house. After World War II, the storage igloos may have been used to store other compounds, including trinitrotoluene (TNT), tetryl, and nitrocellulose. Lease documents indicate UMC occupied this area from 1956 to 1964. Olin also used these igloos for general storage from 1970 through at least 1985. Wildlife Materials, Inc., leased Igloo FS-2-2 from at least 1970 to 1985 for storage of black powder, M6 propellant, and electric squibs. In 1997, the U.S. Army investigated this site to determine if ordnance or explosives remained in the bunkers. A small amount of propellant powder was removed and destroyed.

AUS-0061 (IOP Detonation and Disposal Area)

This site is west of Wolf Creek Road and South of Old Highway 13. "IOP Detonation and Disposal Area" is not an official IOP designation. The site name was developed during the PA/SI investigation as a description of the site, which was apparently used during the IOP era for testing explosives, and for disposal. There are three concrete structures on the "detonation" portion of the site. According to Mr. Wayne Adams, a former Refuge manager, the concrete structures in the "Detonation Area" of the site were used to detonate explosives during World War II. The two westernmost structures are probable detonation pits and the easternmost structure is a probable firing pit. The detonation part of the site includes about ½ acre.

The disposal portion of the site was not investigated during the PA/SI because it was not discovered until the SI field investigation was already in progress. The disposal area is north of the detonation area, and was observed only in the 1943 historical aerial photographs. This area appeared to contain 13 to 15 trenches filled with unidentifiable materials. The overall area of the trenches covers about 20 acres.

The 1951 and 1960 aerial photographs showed evidence of surface dumping in the western part of the former trench area. This activity appeared to be unrelated to the IOP Disposal Area observed in the 1943 photograph. This surface dump was apparently the Job Corps Landfill, which was remediated as part of the PCB OU. That remedy did not address the trenches observed in the 1943 aerial photograph.

There were no known industrial lessees of this property.

AUS-106A (Drum Disposal Area East of Area 11)

This site is located due east of Site AUS-A11N on the north side of an abandoned roadway. The site covers approximately 3,000 square feet (ft) and consists of a mounded area of partially buried drums with some nearby debris. There are an estimated 50 to 100 drums.

The 1951 aerial photograph showed a possible disposal site in this location. There was no evidence of this disposal site in the 1943 aerial photographs. In 1951, portions of the site were vegetated, indicating that they may not have been used for some time. By 1960, this area was completely covered with vegetation and the former farm lane no longer appears on the photo, suggesting that this area had been inactive for some time. This also suggests that an operator/tenant who was at the site prior to 1951 may have been responsible for the drums. These operators/tenants include the SWDC/War Department (operator 1942-1945), Hoosier Cardinal (tenant, 1948 through 1954) or Silas Mason (operator, 1947 through 1950).

SECTION 2

GUIDANCE DOCUMENTS

The primary guidance document that will be used in preparation of the HHRA is the Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (RAGS; USEPA, 1989). This guidance provides the basic framework to be used when conducting a Baseline HHRA. The format of the AUS OU HHRA will be structured in accordance with RAGS. In addition to RAGS, a number of secondary technical resources and/or guidance documents will be used as sources of specific information for selecting chemicals of potential concern, developing exposure assumptions, identifying appropriate toxicity values, etc., that are not specifically identified in RAGS, or which supercede information from RAGS. Specific guidances to be used in the AUS OU HHRA include the following:

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors (OSWER Directive 9285.6-03; USEPA, 1991a).

- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (OSWER Directive 9355.0-30; USEPA, 1991b).

- Supplemental Guidance to RAGS: Calculating the Concentration Term (OSWER Directive 9285.7-08I; USEPA, 1992).

- Superfund's Standard Default Exposure Factors for Central Tendency and Reasonable Maximum Exposure. (USEPA, 1993).

- Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment (USEPA Region IV, 1995a; amended 2001).

- Land Use in the CERCLA Remedy Selection Process (OSWER Directive 9355.7-04; USEPA, 1995b).

- Soil Screening Guidance: User's Guide (OSWER 9355.4-23; USEPA, 1996a).

- Soil Screening Guidance: Technical Background Document (OSWER 9355.4-17A; USEPA, 1996b).

- Technical Review Workgroup for Lead (USEPA, 1996c).

- Exposure Factors Handbook (USEPA, 1997a).

- The Lognormal Distribution in Environmental Applications. (USEPA, 1997b).

- Health Effects Assessment Summary Tables (USEPA, 1997c).

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (OSWER 9355.4-24; USEPA, 2001a).

- Risk Assessment Guidance for Superfund: Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Final (USEPA, 2001b).

- Role of Background in the CERCLA Cleanup Program (OSWER Directive 9285.6-07P; USEPA, 2002a).

- Tiered Approach to Corrective Action Objectives (TACO; IEPA, 2002).

- Evaluating the Vapor Intrusion into Indoor Air (USEPA, 2002b).

- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, 2002c).

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002d).

- Child-Specific Exposure Factors Handbook (USEPA, 2002e).

- Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (USEPA, 2002f).

- Human Health Toxicity Values in Superfund Risk Assessments (OSWER Directive 9285.7-53; USEPA, 2003).

- Preliminary Remediation Goals (USEPA Region IX, 2004a, to be superseded by the current version at the time the risk assessment is performed).

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (USEPA, 2004b).

- Integrated Risk Information System (IRIS) on-line database (USEPA, 2006, to be superceded by the current version at the time the risk assessment is performed).

In the event that one or more of these guidances are updated or replaced by future development of guidance or regional policy, the HHRA will use those guidances/policies that are current at the time of preparation of the HHRA, including use of the most current version of the Region IX Preliminary Remediation Goal Tables for screening chemicals of potential concern (unless general U.S. EPA screening tables are available at that time).

SECTION 3

DATA EVALUATION DISCUSSION

3.1 CHEMICALS OF POTENTIAL CONCERN

The first step in the risk assessment process is the selection process used to refine the preliminary list of COPCs identified in the PA/SI report and subsequent investigations. This group of chemicals, although a subset of all chemicals detected on-site, represents those chemicals posing the greatest potential health risks at the site. Thus, the quantification of potential health risks posed by a site can be focused on the COPCs without significantly underestimating the total risk.

COPCs will be generated for surface soil (0-6 inches below ground surface (bgs)), subsurface soil (0-10 feet bgs), sediments,[4] surface water, and groundwater for the AUS OU sites. Separate COPC lists will be developed for each AUS site, or, in the event that more than one source area/area of contamination is identified at a site, separate lists will be developed for each area of contamination. The maximum detected concentrations will be compared to the following criteria in order to identify the medium-specific COPCs:

- For soil and sediment, screening values will be based on the TACO Industrial/Commercial and Construction Worker Tier I levels (inhalation and ingestion values; IEPA, 2002) and the Region IX industrial PRGs (USEPA, 2004a). PRGs will be modified using the approach recommended by USEPA Region IV (2001) and consistent with Region V policy. As identified in this guidance, carcinogens are to be screened using the standard PRG, based on a target cancer risk of 1E-6 per chemical. Non-carcinogens are to be screened using one tenth the PRG (e.g., based on a target hazard quotient of 0.1 per chemical) to address the concern of potential additive effects of multiple chemicals. [5] In addition to these screening criteria, VOCs in soil gas will also be screened for potential vapor intrusion into buildings using the screening tables presented in *Evaluating the Vapor Intrusion Into Indoor Air* (USEPA, 2002b), based on target cancer risks of 1E-6 per chemical and target hazard quotient of 0.1.

- Site-specific background levels (inorganic compounds only). Consistent with the approach identified in USEPA background guidance (USEPA 2002a, 2002f), chemicals found to be present above health-based screening values, but within background levels will be retained as COPCs for discussion in the uncertainty section of the HHRA.

[4] Sediments from ephemeral water bodies, such as drainage ditches, will be combined with surface soils for evaluation in the HHRA. Sediments from permanent bodies of water will be evaluated separately.

[5] With this modification included, industrial PRGs, which assume daily exposure (i.e., 250 days/year) by adult workers, are also protective of recreational child populations who would visit the Refuge on a less frequent basis, but who overall have a slightly higher non-cancer exposure.

- AWQC values for protection of human health (surface water) and Illinois surface water standards (35 Ill. Adm. Code Part 302). For chemicals with no AWQC values or Illinois surface water standards, the Region IX PRGs for tapwater will be used.

- For groundwater, refinement of COPCs is based primarily on the groundwater classifications established by the State of Illinois. Groundwater at all sites with monitoring wells has been preliminarily classified as either Class I (potable resource groundwater) or Class II (general resource groundwater), based on measured hydraulic conductivity values. All sites will be screened based on the applicable groundwater classification from the hydraulic conductivity testing. If no data are available, groundwater results will be compared with Class I values. For all sites with Class I groundwater, Region IX tapwater levels will be the risk-based screening criteria. In addition to these screening criteria, in the event that soil gas data are not available, VOCs in groundwater will also be screened for potential vapor intrusion into buildings using the screening tables presented in *Evaluating the Vapor Intrusion Into Indoor Air* (USEPA, 2002b), based on target cancer risks of 1E-6 per chemical and target hazard quotient of 0.1 (i.e., for VOCs, the lower of the PRG or vapor intrusion values will be the deciding screening criteria). It is important to note that soil gas data are considered more reliable indicators of potential vapor intrusion than groundwater data.

It is important to note that the health-based screening values used in the COPC screening process (PRGs and TACO values) are updated on a regular basis to reflect changes in toxicity criteria, intake models and exposure parameters. The most current versions of these screening criteria will be used at the time of preparation of the HHRA.

Based on hydraulic conductivity tests, preliminary groundwater COPCs for the following sites will be based on Illinois Class II groundwater standards (this designation may change, based on additional information): AUS-0A2B, -0A2D, -0A2F, -0A4E, -A11A, A11H, -A11P, and -A11S. Preliminary groundwater COPCs for all other sites will be based on Illinois Class I standards/MCLs/Region IX tap water values.

SECTION 4
EXPOSURE ASSESSMENT

The purpose of this section is to identify key exposure assumptions to be used in the HHRA for evaluating potential risks at the AUS OU. The HHRA will specifically address risks associated with contaminated soils, surface water and sediments for those sites identified in the PA/SI as requiring further investigation. Because land use varies from site to site, and because USFWS may want to consider these sites for non-industrial use in the future, a number of exposure scenarios have been developed.

Specific information provided in this document includes the following:

- Identification of current and hypothetical future land uses, as they relate to human receptor populations;

- Identification of potential receptors to be evaluated (i.e., both current populations as well as populations under the reasonably anticipated future land use scenario);

- Identification of potentially complete exposure pathways that will be evaluated quantitatively;

- Identification of exposure assumptions that will be used to estimate exposure among receptors; and

- Identification of models and statistical approaches that will be used to estimate exposure point concentrations of the COPCs.

4.1 LAND USE

4.1.1 Current Land Use

Current land use for each of the AUS OU sites is briefly identified in the site descriptions found in Section 1. At the present time most of the sites fall into one of the following broad categories:

- Active industrial sites with physical access restrictions such as fencing or gates. (Areas 2B, 2D, 2F, 2P, 2R, 6, 9 and 13).

- Active industrial sites and storage areas without physical access restrictions (Areas 3, 4 West, 4 East, 8 South, and 7).

- Sites without industry (Sites 11A, 11H, 11N, 11P, 11S, 12, 10, AUS-0062, AUS-0065, AUS-0066, AUS-0067, AUS-0069, AUS-0001, AUS-0002, AUS-0018, AUS-0043, AUS-0060, AUS-0061, AUS-106A). Note that this category includes sites both with and without physical access controls, such as fencing or locked gates.

4.1.2 Future Land Use Assumptions

The baseline risk assessment will evaluate potential future land use scenarios consistent with USFWS practices and policies for National Wildlife Refuges.

Uncertainty About Future Land Use

Future uses of the Refuge involve an inherent degree of uncertainty. The legislated purposes of the Refuge are wildlife conservation, recreation, agriculture, and industry. With these purposes, a wide range of activities is compatible with refuge purposes. Compatibility is a National Wildlife Refuge System (System) standard to which all refuges are subject (16 U.S.C. § 668dd(a)(3)). Additionally, policies guiding the System change and evolve over time at the discretion of the executive and legislative branches of government. The Refuge, as federal land managed for the benefit of present and future generations of Americans, must maintain its flexibility to adapt to changing wildlife conservation and public use needs

Reasonably Anticipated Future Land Use

As required by the National Wildlife Refuge System Improvement Act of 1997, the Refuge is currently developing a comprehensive conservation plan (CCP) for the Refuge, which will guide Refuge management decisions for a 15-year period. In September 2001, the FWS published a *Project Update* summarizing the status of the CCP planning process[6]. RI/FS and remedial action work will be on-going at the AUS OU sites during the time period covered by the CCP. Because of the uncertainty of the time frame and outcome of RI/FS and remedial action work, the Refuge is not planning specific new uses for the AUS OU sites. However, based on the *Project Update* and discussions with the Refuge management, the following potential future land uses are consistent with current planning and could potentially occur at any of the AUS OU sites:

- Environmental education sites, which would cover relatively small areas (a few acres or less that might include water sampling sites at a pond or lake shoreline, an amphitheater, or simply a location or trail where plants and animals are studied. Summaries of typical sites at other refuges are included in **Appendix A**.

[6] The Project Update is available at http://midwest.fws.gov/planning/craborchard/index.html.

- Hiking trails and bike paths, which could cover relatively large areas,
- Observation areas, which would cover relatively small areas (a few acres),
- Farming (considered a long-term use of relatively large areas),
- Hand-clearing and replanting of trees (likely a one-time use over a relatively short time period); the size of such an area would be difficult to predict, and
- Other wildlife-dependent recreational use, such as photography, hunting, and bank fishing.

In addition, active industrial sites are likely to exist at any current location of industrial activity.

4.2 RECEPTORS

Site receptor populations are typically associated with specific land uses. For active industrial portions of the site, typical receptors could include site workers, site visitors, maintenance workers, excavation workers, or others who might inadvertently come into contact with contaminated surface or subsurface soils, sediments, groundwater or surface water at the facility. Typical receptors in non-industrial areas might include trespassers, hunters, farmers, or USFWS personnel who would visit the sites either frequently or infrequently under current land use. Sites 7[7] and 69 could include fishermen. Future receptors could include any of the current receptors as well as populations associated with the alternative land uses identified above, such as bike path users/hikers, hunters, fishermen, birders, employees of environmental education sites, children or adults on field trips or taking courses, farmers, volunteers for replanting areas, etc. Residential use, expansion of existing campgrounds (which are all outside the AUS OU), or establishment of new campgrounds, are not consistent with current USFWS policy. These uses will not be evaluated in the HHRA.

While it is likely that this list of potential future populations is not comprehensive of all possible future uses, it provides an overview of those types of site uses and associated populations with the greatest potential for significant exposure. Because many of these populations are likely to have similar exposure characteristics (i.e., area, media, and frequency of exposure), the HHRA only needs to evaluate a few of these populations quantitatively in order to determine if the site would pose an unacceptable risk. Based on discussions with USFWS personnel, the following populations were identified for quantitative evaluation in the HHRA. These receptor groups were chosen to allow USFWS flexibility when evaluating possible future uses of the site:

[7] While Crab Orchard Lake is not located adjacent to Area 7, pesticides from Area 7 may have contributed to elevated pesticide levels in the Lake.

- Full-time indoor worker populations. This includes both industrial site workers at active industrial sites and USFWS employees who would be present on a full-time basis at a relatively small facility, such as an environmental education site, and who spend the majority of a typical work day working inside buildings. Indoor workers will be evaluated for potential exposure to site soils, or airborne VOCs released from underlying soils or groundwater into a building, assuming daily exposure throughout the year, over multiple years.

- Full-time outdoor worker populations. This scenario includes both industrial site workers at active industrial sites and USFWS employees who would be present on a full-time basis at a relatively small facility, such as an environmental education site, and who spend the majority of a typical work day working outdoors. Outdoor workers will be evaluated for potential exposure to site soils, assuming daily exposure throughout the year, over multiple years. For sites with surface water or sediment contamination, the scenario will also evaluate infrequent exposure to these media over multiple years.

- Individuals in a semi-confined space (e.g., a trench) who might be exposed to subsurface soils, or airborne VOCs released from those soils or underlying groundwater, during typical excavation activities such as construction, utility repair, tree planting, land reclamation, etc. (referred to generically in the HHRA as “excavation workers”). It should be noted that USEPA considers the excavation scenario to be an upperbound exposure scenario, and does not recommend evaluating CTE for this scenario. For this reason, only RME exposure assumptions are provided in the following sections for the excavation worker.

- Recreational users of the facility, including both adults and children, who would be expected to be present at a relatively small portion of the site on a part-time basis, and who would be exposed to site surface soils, surface water or sediment. Although this population will be evaluated in the HHRA as if it were a single receptor group, in reality it encompasses a large, diverse group of individuals with similar exposure potential. Receptors in this group would include birders, students at an environmental education site, hunters, anglers, visitors at an observation area, etc. While this scenario is primarily intended to address future land use, it should also provide a protective evaluation for current USFWS workers who visit various sites on an infrequent basis, as well as hikers and farmers who could be exposed on an infrequent basis to relatively large areas that include both contaminated and uncontaminated property. It should be noted that, in the event that the results of the Ecological Risk Assessment indicate that COPCs could potentially bioaccumulate into the tissues of game species, the HHRA will be expanded to include an evaluation of ingestion of game by hunters.

- Anglers who would fish in areas containing contaminated soil (site 0069 only), sediment or surface water, and who could come into direct contact with the soil, sediment and surface water, and eat the fish from this area.

- Agricultural workers who could be exposed to soil and dust generated from fields during various agricultural activities (seeding, spraying, harvesting, etc.).

Workers, excavation workers and recreational users will be evaluated for each AUS OU site, including those that are currently industrial. Anglers and agricultural workers will only be evaluated for those sites where such activities could occur.

4.2.1 Exposure Areas

For purposes of the risk assessment, sites will be organized into one or more discrete areas for evaluation (i.e., “exposure areas” (EA)). As described in the Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA, 1992), an EA (or exposure unit, EU) is the area over which an individual is assumed to move randomly, spending equivalent amounts of time in each location. The soil contaminant concentration contacted over time is represented by the averaged concentrations over the EA. Delineation of EAs also must consider release areas. Combining multiple release areas in a single EA is generally not appropriate, because the contaminant concentrations do not represent a single population.

Based on an evaluation of release areas, a review of land uses at other USFWS Refuges (see **Appendix A**), and planned future uses as described by the Refuge staff and currently being developed for the comprehensive conservation plan for the Refuge, EAs of two acres appear to be appropriate for most non-industrial scenarios. EAs of this size should be adequate to evaluate risks for a number of potential future uses, including environmental centers, observation areas, hiking trails, birding, bike trails, farming, hand-clearing and revegetation of selected areas, and tree-planting.

4.3 EXPOSURE PATHWAYS

An exposure pathway is the mechanism by which a receptor may come into contact with a chemical. As defined in the Risk Assessment Guidance for Superfund (RAGS; USEPA, 1989), there are four major elements that characterize a complete exposure pathway. These elements are:

1. A source and mechanism of chemical release;

2. A point of potential receptor contact with the medium (i.e., an exposure point);
3. A receptor population at the exposure point; and
4. A route of exposure (e.g. ingestion) for the receptor to come into contact with the chemical.

For an exposure pathway to be complete, all four elements must be present. The absence of any one of these elements results in an incomplete exposure pathway for which site-related health risks do not exist. Thus, the evaluation of potential exposure pathways is necessary to focus on only those pathways that are complete and that could potentially impact human health.

To develop a conceptual understanding of the sites and their potential to impact human health and environment, six site conceptual exposure models (SCEMs) were developed, based on current site use (i.e., industrial vs. non-industrial) and the nature of contaminated media found at each site (soil, sediment, surface water). The SCEMs provide a means of identifying potentially complete exposure pathways where significant exposure could occur. Potentially significant pathways are evaluated quantitatively in the HHRA.

Because the SCEMs are conceptual in nature, sites with similar release, transport and exposure characteristics can be grouped into a single SCEM. **Figure 2** depicts the SCEM for active industrial sites with known contamination of both site soil and surface water/sediment, but no suspected impact to fish (i.e., Sites 2B, 2D, 2F, 2P, 4 East, and 8 South). **Figure 3** depicts the SCEM for one active industrial site with known contamination of both site soil and surface water/sediment, and suspected impact to fish (i.e., Site 7). **Figure 4** is the SCEM for active industrial sites with contaminated soil (i.e., Sites 2R, 4 West, 6, 9, and 13). **Figure 5** is the SCEM for non-industrial sites with known contamination of both site soil and surface water/sediment (i.e., Sites 10, 11A, 11H, 11N, 11P, 11S, 12, AUS-0002, AUS-0043, AUS-0062, and AUS-0066). **Figure 6** is the SCEM for one non-industrial site with known contamination of both site soil and surface water/sediment, and suspected impact to fish (i.e., Site AUS-0069). **Figure 7** is the SCEM for non-industrial sites with known contamination of site soil only (Sites AUS-0001, AUS-0018, AUS-0060, AUS-0061, AUS-0065, AUS-0067, and AUS-106A). These models specifically identify chemical release mechanisms, transport media, exposure routes and receptor populations. The RAGS D tables ("Selection of Exposure Pathways", RAGS D Tables 1.1 through 1.6)) that correspond to these SCEMs are presented in **Appendix B**.

An evaluation of potential sources of chemical release for each site is beyond the scope of this TM, however, the initial releases are assumed to be due to spills and waste products that were handled during past operations at the various facilities. A discussion of exposure media and exposure routes is presented in the following sections. Potential receptor populations were identified previously.

SECTION 4
EXPOSURE ASSESSMENT

Once released to the soil, contaminants could be transported via any or all of the following mechanisms:

- Into deeper soils or groundwater (if present) via leaching mechanisms,
- Into the atmosphere via volatilization or dust generation from windblown actions or soil disturbances,
- Into buildings or semi-confined spaces (trenches) overlying contaminated soils or groundwater via volatilization,
- Into surface water and sediment via runoff or migration of contaminated groundwater,
- Into the human food chain via uptake from contaminated sediment or surface water (fish, fish-eating waterfowl) or from soil (herbivores such as deer).

Exposure potentially can occur if individuals come into contact with these contaminated media. Potential exposure routes could include direct dermal contact, ingestion (i.e., either incidental ingestion via hand-to-mouth activity or direct ingestion through the food chain), or inhalation of volatilized contaminants or particulate matter. More detailed discussion follows.

Soil is the primary medium of concern at the AUS OU. Any receptor population present in a contaminated portion of the AUS OU is likely to be exposed to soil via direct dermal contact and incidental ingestion. Both of these exposure routes are considered potentially complete and significant for all relevant receptor populations, and will be evaluated quantitatively in the HHRA for any site or portion of a site with identified soil COPCs.

A number of surface water bodies are present at the Refuge within the boundaries of the various AUS OU sites. Contamination has been observed in surface water, sediment, or both, from a number of these sites. Exposure to contaminated surface water or sediment could occur when an individual enters the water (wading, fishing, playing, etc.). Significant exposure potentially could occur via direct dermal contact and incidental ingestion anytime COPCs are identified in these media, and will be evaluated in the HHRA.

Exposure to contaminated dust or vapors outdoors could be a potentially complete exposure route in the case of exposed surface soil or excavation of contaminated subsurface soils (dust), or if surface soil, subsurface soil or shallow groundwater contains significant levels of VOCs (volatile emissions). While it is likely that these pathways are minor for some of the AUS sites, relative to direct contact pathways, they will be evaluated quantitatively in the HHRA if the data indicate them to be potentially complete pathways. Populations that will be evaluated include anglers, recreational users, excavation workers and site workers. Potential dust and VOC releases will be estimated using the methodologies specified in the Soil Screening Level

Guidances (USEPA 1996a, 1996b, 2002e) for developing Particulate Emission Factors (PEFs) and Volatilization Factors (VFs).

In addition to outdoor exposures, VOCs from subsurface soil or underlying groundwater could volatilize and be transported in significant quantities into overlying buildings or into semi-confined areas, such as excavation trenches. Releases of VOCs into indoor air and excavation trenches will be evaluated for site worker and excavation worker scenarios, respectively.

The human food chain could be affected if potentially toxic, bioaccumulative compounds are present in surface water and/or sediments in water bodies that are fished. Fishing represents a potentially compete exposure pathway for a few sites adjacent to fishable water bodies, and will be evaluated quantitatively in the HHRA. Likewise the potential exists for bioaccumulation into waterfowl that eat fish, or herbivores such as deer, that graze in areas of contaminated surface soil. Areas at the AUS OU that allow hunting will be evaluated quantitatively for food chain effects from eating game animals if the Ecological Risk Assessment indicates that significant biouptake is possible in those areas. This evaluation will require close coordination between the ecological risk assessment team and the HHRA team. If this scenario is found to warrant evaluation, site-specific exposure parameters will be developed at the time the risk assessment is performed to account for the species of concern, hunting regulations (i.e., “take” limits), etc.

4.4 EXPOSURE ASSUMPTIONS

A number of exposure parameters must be quantified in order to calculate the chronic daily intake (CDI) of chemicals from exposure to contaminated soils, sediment, and surface water, and to estimate the associated potential health risks. The exposure parameter values used in the exposure algorithms have been selected from a variety of sources, including the Exposure Factors Handbook (USEPA, 1997a), OSWER Directive 9285.6-03 (Standard Default Exposure Factors; USEPA, 1991a), Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2001a), and Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989) or developed using site-specific information and professional judgement. The exposure parameters listed in **Table 1** will be incorporated into the exposure algorithms to estimate CDI and site risks. The corresponding RAGS D tables (“Values Used for Daily Intake Calculations”, RAGS D Tables 4.1 RME through 4.13 RME, and 4.1 CT through 4.13 CT) are presented in **Appendix B**.

Reasonable Maximum Exposure (RME) assumptions will be used to evaluate all scenarios. In the event that a site is found to pose an unacceptable risk or hazard based on the RME scenario, Central Tendency Exposure (CTE) scenarios will also be evaluated. Parameters required for the evaluation include the following:

- Soil/sediment ingestion rate (mg/day)
- Surface water ingestion rate (ml/day)
- Inhalation rate (m^3/day)
- Fish Ingestion Rate (kg/day)
- Exposed skin surface area (cm^2)
- Soil/sediment adherence rate (mg/cm^2)
- Dermal absorption from soil/sediment (unitless)
- Dermal permeability constant (cm/hour)
- Exposure time (hours/day)
- Exposure frequency (days/year)
- Exposure duration (years)
- Body weight (kg)
- Averaging time (days) for both carcinogens and non-carcinogens

Each of these exposure parameters is discussed below.

4.4.1 Soil/Sediment Ingestion Rate

The soil/sediment ingestion rate refers to the amount of soil and/or sediment that is ingested daily due to incidental ingestion (e.g., hand-to-mouth contact). For purposes of evaluating risks, the soil and sediment ingestion rates are assumed to be the same. For indoor worker populations, an ingestion rate of 50 mg/day will be used to evaluate RME and CTE ingestion (USEPA 1991a; 1993). For outdoor workers, an ingestion rate of 100 mg/day will be assumed for RME and 50 mg/day will be assumed for CTE, as recommended in USEPA (1993). These indoor and outdoor values will be used in the HHRA to evaluate industrial workers and USFWS employees (i.e., all “worker” populations). For adult recreational users, including anglers, an adult resident ingestion rate of 100 mg/day will be used to evaluate RME (USEPA, 1991). An ingestion rate of 50 mg/day will be used to evaluate CTE ingestion based on the recommended values for adult residents (USEPA, 1993). Because the recreational users, including anglers, are likely to include children as well as adults, residential child ingestion rates of 200 mg/day (RME) and 100 mg/day (CTE) will be used to evaluate potential child exposure for these scenarios (USEPA, 2002e).

For excavation workers, it is assumed that work performed at the site will be more "contact intensive" with soil than for general worker populations. The Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2001a; OSWER 9355.4-24) recommends an RME ingestion rate of 330 mg/day for evaluating this type of exposure, based on a study by Stanek et al. (1997).

4.4.2 Surface Water Ingestion Rate

Surface water is not used as a drinking water source, nor is swimming likely, at any of the AUS OU sites. Similar to soil, ingestion of small quantities of surface water could occur due to incidental contact. There is very little quantitative information available regarding incidental ingestion rates for surface water. RAGS (USEPA, 1989) recommends the use of 50 ml/hour (0.05 L/hour) for evaluating surface water ingestion by swimmers. This is roughly equivalent to swallowing a mouthful of water every hour. It is unlikely that any of the populations present at the AUS OU sites would ingest 50 ml/hour of surface water, indeed, exposure is likely to be a fraction of this amount. For purposes of evaluating potential risks in the HHRA, the RME surface water ingestion rate will be assumed as 50 ml/day (0.05 L/day). A CTE ingestion rate of 17 ml/day will be used for both child and adult exposures. The child CTE value is based on data presented in Table 9-30 of the Child-Specific Exposure Factors Handbook (USEPA, 2002e) that indicates that the mean time spent swimming is approximately a third of the high-end (90th percentile) exposure time. The adult CTE value is based on data presented in Table 15-67 of the Exposure Factors Handbook (USEPA, 1997a) that shows the same ratio for adults[8]. It is important to recognize that while there is a significant level of uncertainty associated with these assumed values, especially since the ingestion values are based on swimming rather than the type of incidental contact likely at the site (wading, hand rinsing, etc.). It is unlikely that any receptor populations would drink more than this amount of surface water over a typical day. Use of these high-end values should provide a protective evaluation of potential risks.

4.4.3 Inhalation Rate

[8] The data presented in the Child-Specific Exposure Factors Handbook Table 9-30 and in the Exposure Factors Handbook Table 15-67 are both derived from the same consumer survey conducted by Tsang and Klepeis (1996).

Inhalation exposure of non-carcinogens will be evaluated by comparing the air exposure point concentrations to the appropriate reference concentrations, instead of calculating hazard indices based on reference doses. For carcinogens, the default inhalation rate of 20 m^3/day (USEPA, 2002d) will be used to evaluate all scenarios, for both RME and CTE scenarios. Indoor air risks will be calculated using the Johnson and Ettinger model per USEPA's "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" (USEPA, 2002b).

4.4.4 Fish Ingestion Rate

The fish ingestion rate refers to the total amount of fish consumed from all sources, averaged over an annual (365 day) time period. Ingestion rates of 0.025 kg/day (RME) and 0.008 kg/day (CTE), as recommended in Section 10.10.3 of the Exposure Factors Handbook (USEPA, 1997a) will be used to evaluate adult ingestion. These values are based on the 95th percentile (RME) and 50th percentile (CTE) ingestion rates for recreational freshwater anglers. Child ingestion rates will be based on the "as consumed" ingestion rates for freshwater and estuarine fish for children aged 14 and younger, as identified in the Child-Specific Exposure Factors Handbook (USEPA, 2002e; Table 3-20). The RME value will be 0.0139 kg/day (95th percentile) and the CTE value will be 0.00188 kg/day (50th percentile).

4.4.5 Exposed Skin Surface Area

Exposed skin surface area is important when evaluating uptake of chemicals that are absorbed dermally. For dermal exposure to soil, a surface area of 3,160 cm^2 will be used to evaluate RME exposure for all adult receptors, and 1,910 cm^2 for 0-6 year old children. These values are based on the surface areas of hands, head, and forearms (Exposure Factors Handbook; USEPA, 1997a). Because the legs and feet could be exposed during wading in surface water, higher surface areas will be assumed for potential exposure to surface water and sediment. For dermal exposure to surface water and sediment, a surface area of 6,350 cm^2 will be used to evaluate RME for all adult receptors, and 3,122 cm^2 for 0-6 year old children. These values are based on the surface areas of hands, head, forearms, feet and lower legs (USEPA, 1997a). As recommended in USEPA dermal guidance (USEPA, 2004b), the RME surface area will also be used to evaluate CTE exposure[9].

4.4.6 Soil/Sediment Adherence Rate

[9] As identified in USEPA (2004b), CTE dermal exposure is to be differentiated from RME exposure based on changes in exposure frequency and dermal adherence rate, not surface area.

Dermal soil adherence is used, in conjunction with exposed skin surface area, to define the total amount of soil adhering to exposed skin surfaces. Based on USEPA recommendations (USEPA, 2001a, 2004b), an RME adherence rate of 0.2 mg/cm^2 will be used to evaluate industrial workers and USFWS employees, and 0.3 mg/cm^2 will be used to evaluate high soil contact scenarios for adults (excavation workers, recreational users, and anglers). For child recreators and anglers, an RME adherence rate of 0.4 mg/cm^2 will be applied based on the 95th percentile for children playing in dry soil (USEPA, 2004b). CTE adherence rates assume less intense soil contact. The CTE for workers will be 0.1 mg/cm^2, based on the average of eight different geometric mean values listed for commercial/industrial adults (USEPA, 2004b). The CTE for child recreators and anglers will be 0.04 mg/cm^2, which is the geometric mean for children playing in dry soil, and the CTE for adult recreators and anglers will also be 0.04 mg/cm^2, based on the geometric mean for resident adults involved in landscape/rockery activities (USEPA, 2004b).

4.4.7 Dermal Absorption

Dermal absorption values are used to estimate chemical absorption from soil or sediment through the skin. Dermal absorption will be evaluated using the recommended absorption rates from RAGS Part E (USEPA, 2004b). For VOCs and most metals, absorption is assumed to be 0% (i.e., these chemicals are not readily absorbed from a soil matrix). For most SVOCs, a default value of 10% is recommended. RAGS Part E recommends chemical-specific values for a handful of metals and SVOCs. In the event that any of the COPCs fall into this category, the recommended chemical-specific absorption rates will be used.

4.4.8 Dermal Permeability Constant

The permeability constant is a chemical-specific measure of dermal absorption from water. RAGS Part E provides permeability constants for a large number of chemicals. Wherever available, dermal permeability constants from RAGS Part E (USEPA, 2004b) will be used. For organic chemicals not listed in RAGS Part E, permeability constants will be calculated based on chemical's octanol-water partition constant (K_{ow}), using the conversion equation presented in this guidance. For metals not listed in this guidance, a generic permeability constant of 0.001 cm/hour will be used.

4.4.9 Exposure Time

The exposure time is used to evaluate dermal absorption from water and inhalation. For evaluating dermal exposure, an exposure time of 2 hours per day will be assumed for all RME scenarios. For CTE, one third the RME value will be assumed (rounded to 1 hour per day). As discussed in Section 4.4.2, the child CTE value is based on data presented in Table 9-30 of the

Child-Specific Exposure Factors Handbook (USEPA, 2002e) that indicates that the mean time spent swimming is approximately a third of the high-end (90^{th} percentile) exposure time. The adult CTE value is based on data presented in Table 15-67 of the Exposure Factors Handbook (USEPA, 1997a) that shows the same ratio for adults. It is important to recognize that there is a significant level of uncertainty associated with these assumed values, and that it is unlikely that any receptor populations would spend this much time in direct contact with surface water over a typical day. Use of these high-end values should provide a protective evaluation of potential risks.

For evaluating inhalation exposure of carcinogenic compounds, an exposure time of 8 hours/day will be used to evaluate all scenarios. Non-carcinogens will be evaluated using a reference concentration approach, which does not typically require exposure time as an input parameter.

4.4.10 Exposure Frequency

Exposure frequency refers to the number of days per year that an individual is exposed to site contaminants. For sediment and soil exposure the event frequency is assumed to be one event per day of exposure. Typically, the exposure frequency would be equal to the number of days per year that an individual spends on-site. In the case of worker exposure to surface water or sediment, exposure is likely to be infrequent, since it is unlikely that their job duties would require them to be exposed to surface water bodies on a regular basis.

An RME exposure frequency of 250 days/year will be assumed for soil contact and inhalation pathways for indoor workers and 225 days/year for outdoor workers, based on the standard default values for these populations (USEPA, 2002d). For surface water and sediment pathways, an exposure frequency of 26 days/year (i.e., once per week during the warmest 6 months of the year) will be used to assess RME workers. While this value undoubtedly overestimates exposure by most industrial workers, who are likely to have very little direct contact with these media, it may be realistic for USFWS personnel at an environmental education center. A CTE frequency of 219 days/year, as presented in USEPA (1993, 1996c, 2004b) for commercial/industrial workers, will be used to evaluate exposure to soil, and 13 days/year will be used to evaluate exposure to surface water and sediment. The CTE rate for surface water/sediment assumes that workers will not spend every day in direct contact with contaminated media, because of other job duties, inclement weather that makes the media inaccessible, etc.

As discussed earlier, excavation workers at the refuge would most likely consist of individuals performing some type of underground utility repair, planting of trees, or construction activities. USEPA (2002d) presents 250 days/year as a standard default RME exposure frequency for construction workers.

There is a great deal of uncertainty with regard to exposure frequency for the various recreational populations at the Refuge. While some individuals in these groups may only visit the refuge a few times a year, others may visit on a regular basis. For purposes of evaluating potential risks, the assumption will be made that these populations could visit the Refuge 52 days per year for the RME (i.e., two times per week for the warmer 6 months of the year) and 26 days per year for CTE (half the RME rate). Discussions with USFWS personnel at the Refuge indicate that some individuals are seen almost every weekend during the warmer months fishing at the Refuge, consistent with the RME assumption. While there may be a few individuals that visit the Refuge on a more frequent basis, this is probably a realistic estimate for representative upperbound exposure.

It should be noted that the daily ingestion rates that are used to evaluate ingestion of fish are average daily rates based on a 365 day/year averaging period. As such, the exposure frequency used to evaluate these pathways is 365 days/year.

4.4.11 Exposure Duration

Exposure duration refers to the number of years in which exposure occurs. USEPA has identified a “default” RME exposure duration of 25 years for evaluating worker exposure (SDEF, USEPA, 1991). This value will be applied to worker populations. For the CTE worker scenarios, an exposure duration of 5 years will be assumed. This value is based on information supplied by the Bureau of Labor Statistics (U.S. Department of Labor, 1987) showing 5 years to be the average time an individual spends at one job.

Excavation work is considered a plausible future site-specific intrusive activity. This type of activity generally occurs over a relatively short duration. The default exposure duration identified in USEPA (2002e) for excavation work is one year.

Anglers and other recreational receptors are assumed to be members of the local community. Residential exposure durations will be used to evaluate these populations. For the RME, an exposure duration of 30 years will be assumed, based on the 90th percentile duration of residence in a single house (SDEF, USEPA, 1991a, 1997a). For the CTE, an exposure duration of 9 years will be assumed, based on the 50th percentile duration of residence in a single location (USEPA, 1997a, Section 15.4.3). Because both children and adults are likely to be present, the exposure duration will be partitioned between these two groups. For the RME scenarios, the 30 year exposure duration will be partitioned to evaluate 6 years as a child and 24 years as an adult. For the CTE scenarios, the exposure duration will be partitioned as 6 years for a child and 3 years as an adult. This approach addresses the higher exposure potential of small children, and is typically used when a mixed age population is potentially exposed.

4.4.12 Body Weight

Default body weights for adults were obtained from SDEF (USEPA, 1991a). The assumed adult body weight of 70 kg will be used to evaluate all adult receptors for both RME and CTE. A body weight of 15 kg will be used to evaluate both RME and CTE exposure among children, based on the mean body weight for a 0-6 year old child.

4.4.13 Averaging Time

Carcinogens – Lifespan is used as the averaging time for evaluation of cancer risks. The assumed lifespan, provided as a default value in SDEF (USEPA, 1991a), is 25,550 days (70 years) for all receptors for both RME and CTE.

Non-Carcinogens – The averaging time used to evaluate non-carcinogenic effects is equal to the total duration of exposure. For worker populations (industrial workers and USFWS employees), the RME averaging time is 9,125 days (25 years), and the CTE averaging time is 1,825 days (5 years). For the excavation worker scenario the averaging time for the RME scenario will be 365 days (1 year). For anglers and recreational receptors, the CTE averaging time will be 3,285 days (9 years), and the RME averaging time will be 10,950 days (30 years).

4.5 EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations are the chemical concentrations to which a receptor is exposed when contact is made with a specific environmental medium. Where possible, exposure point concentrations will be calculated separately for each contaminated medium (surface soil, subsurface soil, sediment and surface water) for each exposure area, based on the 95% Upper Confidence Limit on the mean of the data using the methods described in “Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites” (USEPA, 2002c).

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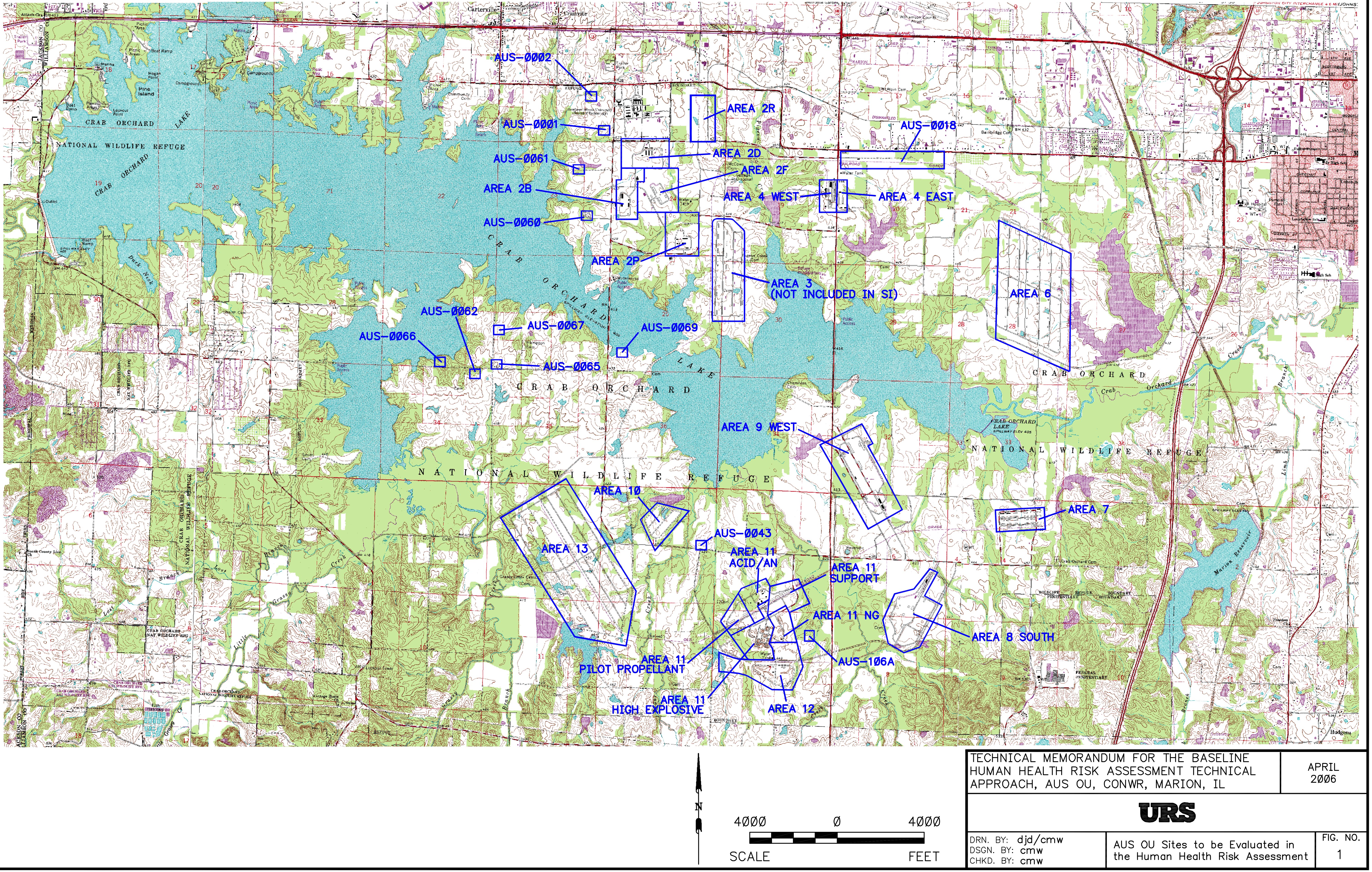
Table 1
Exposure Parameters
AUS OU
Crab Orchard National Wildlife Refuge
Marion, Illinois

Exposure Parameters	Indoor Worker		Outdoor Worker		Excavation Worker		Recreational User		Angler	
	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Adult Soil/Sediment Ingestion Rate (mg/day)	50	50	50	100	NE	330	50	100	50	100
Child Soil/Sediment Ingestion Rate (mg/day)	-	-	-	-	-	-	100	200	100	200
Adult Surface Water Ingestion Rate (ml/day)	-	-	17	50	-	-	17	50	17	50
Child Surface Water Ingestion Rate (ml/day)	-	-	-	-	-	-	17	50	17	50
Adult Inhalation Rate (m^3/day)	20	20	20	20	NE	20	20	20	20	20
Adult Fish Ingestion Rate (kg/day)	-	-	-	-	-	-	-	-	0.008	0.025
Child Fish Ingestion Rate (kg/day)	-	-	-	-	-	-	-	-	0.00188	0.0139
Exposed Skin Surface Area for an Adult[a] - soil (cm^2)	3,160	3,160	3,160	3,160	NE	3,160	3,160	3,160	3,160	3,160
Exposed Skin Surface Area for a Child - soil (cm^2)	-	-	-	-	-	-	1,910	1,910	1,910	1,910
Exposed Skin Surface Area for an Adult - sediment & surface water (cm^2)	-	-	6,350	6,350	-	-	6,350	6,350	6,350	6,350
Exposed Skin Surface Area for a Child - sediment & surface water (cm^2)	-	-	-	-	-	-	3,122	3,122	3,122	3,122
Adult Soil/Sediment Adherence Rate (mg/cm^2)	0.1	0.2	0.1	0.2	NE	0.3	0.04	0.3	0.04	0.3
Child Soil/Sediment Adherence Rate (mg/cm^2)	-	-	-	-	-	-	0.04	0.4	0.04	0.4
Dermal Absorption from Soil/Sediment (Unitless)	Chemical Specific									
Dermal Permeability Constant (cm/hr)	Chemical Specific									
Exposure Time - Dermal exposure to water (hr/day)	-	-	1	2	NE	2	1	2	1	2
Exposure Time - Inhalation (hr/day)	8	8	8	8	NE	8	8	8	8	8
Exposure Frequency (days/year)	219	250	219/13[b]	225/26[b]	NE	250	26	52	26	52
Exposure Frequency - Food Chain (days/year)	-	-	-	-	-	-	-	-	365	365
Exposure Duration (years)	5	25	5	25	NE	1	9	30	9	30
Adult Body Weight (kg)	70	70	70	70	NE	70	70	70	70	70
Child Body Weight (kg)	-	-	-	-	-	-	15	15	15	15
Averaging Time for Non-carcinogens (days)	1,825	9,125	1,825	9,125	NE	365	3,285	10,950	3,285	10,950
Averaging Time for Carcinogens (days)	25,550	25,550	25,550	25,550	NE	25,550	25,550	25,550	25,550	25,550

NE - Not evaluated. USEPA considers an excavation scenario an upperbound exposure scenario, and does not recommend evaluating CTE for this scenario.

[a] The adult skin surface area for exposure to soils was derived from the Exposure Factors Handbook (USEPA, 1997a) and differs slightly from the value of 3,300 cm^2 listed in RAGS E (USEPA 2004b) for construction workers.

[b] Outdoor Worker exposure to air and soil pathways will be evaluated for 225 days/year (RME) and 219 days/year (CTE). Outdoor Worker exposure to surface water and sediment pathways will be evaluated for 26 days/year (RME) and 13 days/year (CTE).



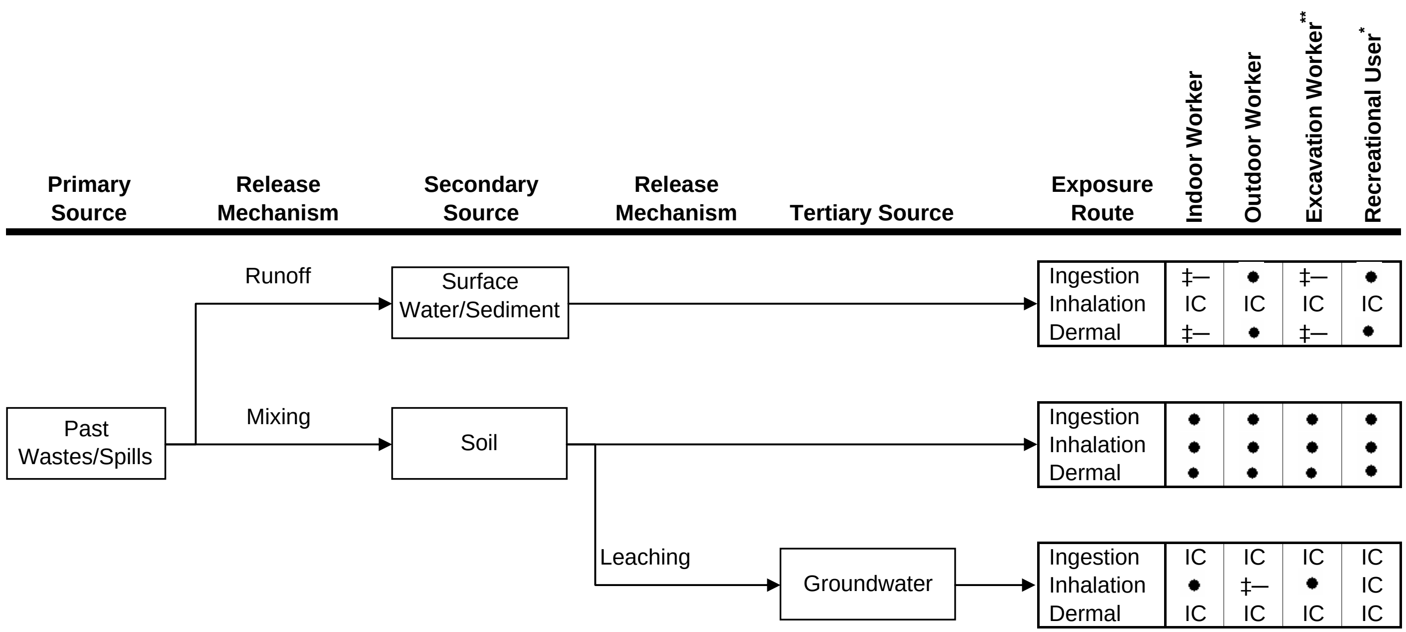
TECHNICAL MEMORANDUM FOR THE BASELINE HUMAN HEALTH RISK ASSESSMENT TECHNICAL APPROACH, AUS OU, CONWR, MARION, IL	APRIL 2006

URS

DRN. BY: djd/cmw DSGN. BY: cmw CHKD. BY: cmw	AUS OU Sites to be Evaluated in the Human Health Risk Assessment	FIG. NO. 1

File: P:\ENVIRONMENTAL\CRAB O (AUS)\RISK - HH AND ECOLOGICAL\RISK - HUMANHEALTH_TECHNICAL MEMORANDUMS_FINAL TECHNICAL MEMORANDUM - 2006_SUBMITTED APRIL 2004\FIGURE 1.DWG Last edited: 04/19/06 @ 10:13 a.m. @ WCC-ST.LOUIS

Figure 2
Site Conceptual Exposure Model
Active Industrial Sites with Soil and Surface Water/Sediment Contamination
Sites 2B, 2D, 2F, 2P, 4 East, and 8 South
AUS OU
Crab Orchard National Wildlife Refuge
Marion, Illinois

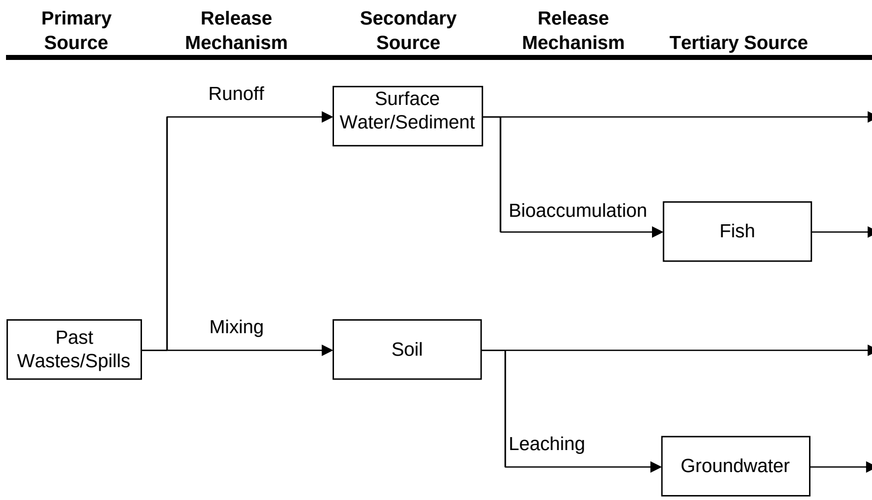


Legend: —— Complete Migration Pathway
- - - - Incomplete Migration Pathway
● Potentially Complete Exposure Route
IC Incomplete Exposure Route

* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

Figure 3
Site Conceptual Exposure Model
Active Industrial Sites with Soil and Surface Water/Sediment Contamination
Site 7
AUS OU
Crab Orchard National Wildlife Refuge
Marion, Illinois



Tertiary/Secondary Source	Exposure Route	Indoor Worker	Outdoor Worker	Excavation Worker**	Recreational User*	Angler***
Surface Water/Sediment	Ingestion	‡—	●	IC	●	●
	Inhalation	IC	IC	IC	IC	IC
	Dermal	‡—	●	IC	●	●
Fish	Ingestion	IC	IC	IC	IC	●
	Inhalation	IC	IC	IC	IC	IC
	Dermal	IC	IC	IC	IC	IC
Soil	Ingestion	●	●	●	●	IC
	Inhalation	●	●	●	●	●
	Dermal	●	●	●	●	IC
Groundwater	Ingestion	IC	IC	IC	IC	IC
	Inhalation	●	‡—	●	IC	IC
	Dermal	IC	IC	IC	IC	IC

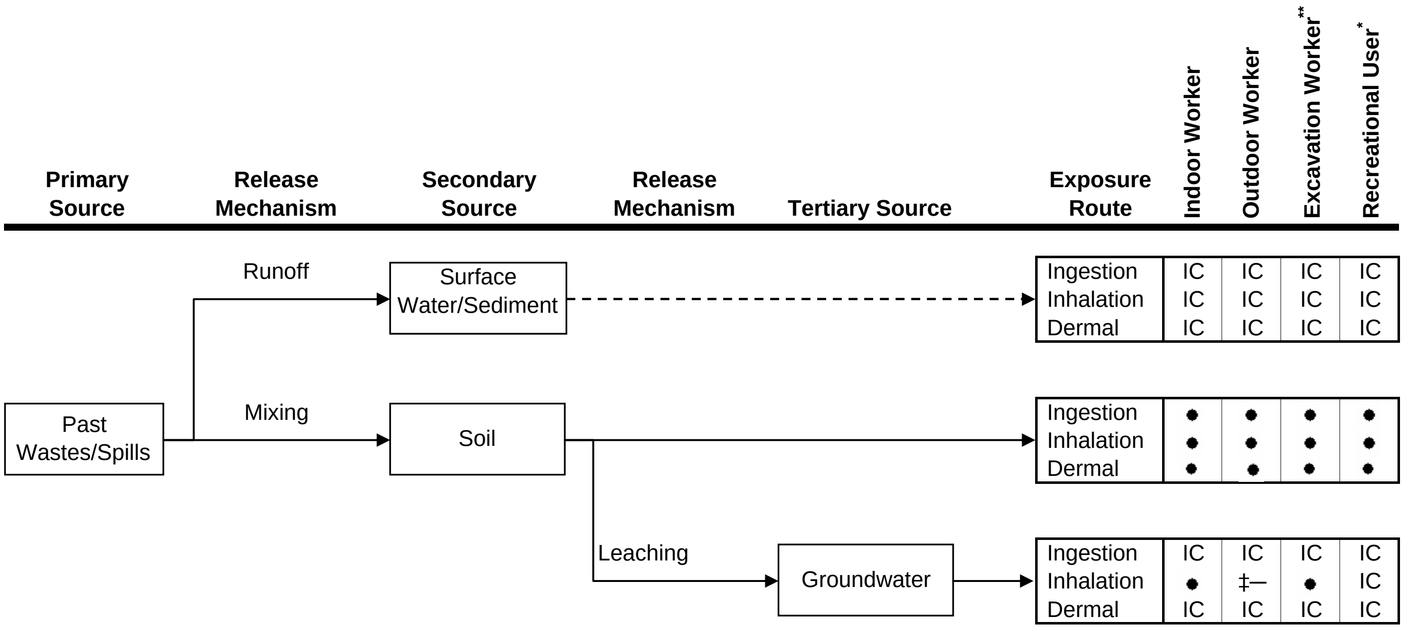
Legend: —— Complete Migration Pathway
-·-·- Incomplete Migration Pathway
● Potentially Complete Exposure Route
IC Incomplete Exposure Route

* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

*** Anglers at Crab Orchard Lake. While Crab Orchard Lake is not located adjacent to Area 7, pesticides from Area 7 may have contributed to elevated pesticide levels in the Lake.

Figure 4
Site Conceptual Exposure Model
Active Industrial Sites with Soil Contamination
Sites 2R, 4 West, 6, 9, and 13
AUS-OU
Crab Orchard National Wildlife Refuge
Marion, Illinois

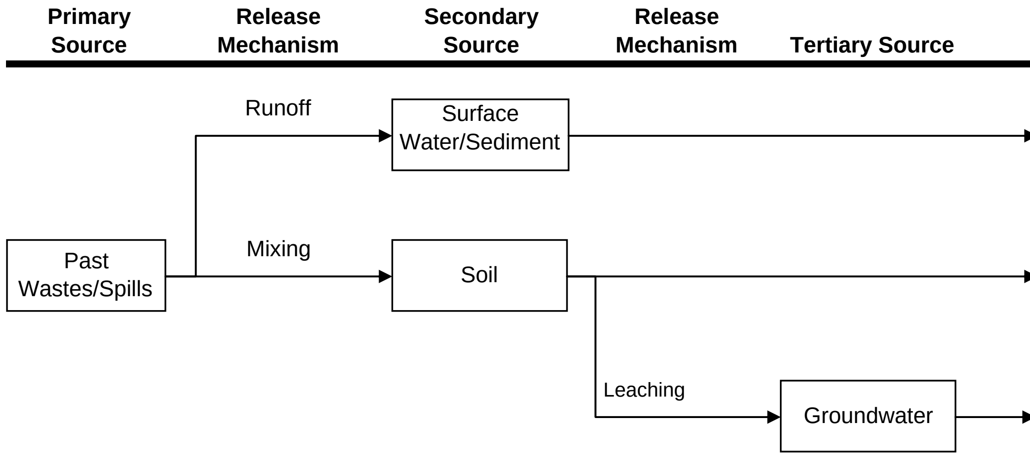


Legend: —— Complete Migration Pathway
- - - - Incomplete Migration Pathway
● Potentially Complete Exposure Route
IC Incomplete Exposure Route

* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

Figure 5
Site Conceptual Exposure Model
Non-Industrial Sites with Soil and Surface Water/Sediment Contamination
Sites 10, 11A, 11H, 11N, 11P, 11S, 12, AUS-0002, AUS-0043, AUS-0062, and AUS-0066
AUS OU
Crab Orchard National Wildlife Refuge
Marion, Illinois



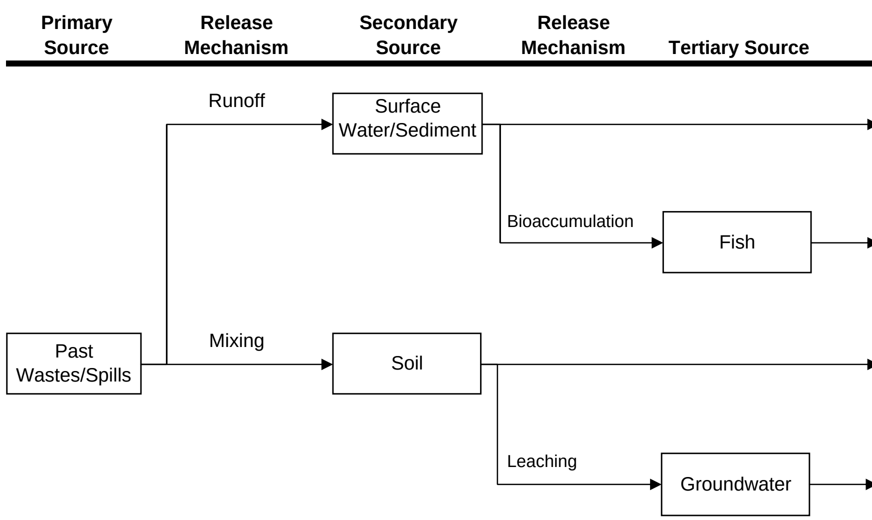
Source	Exposure Route	Indoor Worker	Outdoor Worker	Excavation Worker**	Recreational User*
Surface Water/Sediment	Ingestion	IC	●	IC	●
	Inhalation	IC	IC	IC	IC
	Dermal	IC	●	IC	●
Soil	Ingestion	●	●	●	●
	Inhalation	●	●	●	●
	Dermal	●	●	●	●
Groundwater	Ingestion	IC	IC	IC	IC
	Inhalation	●	‡—	●	IC
	Dermal	IC	IC	IC	IC

Legend: ——— Complete Migration Pathway
-·-·-·- Incomplete Migration Pathway
● Potentially Complete Exposure Route
IC Incomplete Exposure Route

* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

Figure 6
Site Conceptual Exposure Model
Non-Industrial Sites with Soil and Surface Water/Sediment Contamination
Site 0069
AUS OU
Crab Orchard National Wildlife Refuge
Marion, Illinois



Secondary/Tertiary Source	Exposure Route	Indoor Worker	Outdoor Worker	Excavation Worker**	Recreational User*	Angler***
Surface Water/Sediment	Ingestion	IC	●	IC	●	●
	Inhalation	IC	IC	IC	IC	IC
	Dermal	IC	●	IC	●	●
Fish	Ingestion	IC	IC	IC	IC	●
	Inhalation	IC	IC	IC	IC	IC
	Dermal	IC	IC	IC	IC	IC
Soil	Ingestion	●	●	●	●	●
	Inhalation	●	●	●	●	●
	Dermal	●	●	●	●	●
Groundwater	Ingestion	IC	IC	IC	IC	IC
	Inhalation	●	‡—	●	IC	IC
	Dermal	IC	IC	IC	IC	IC

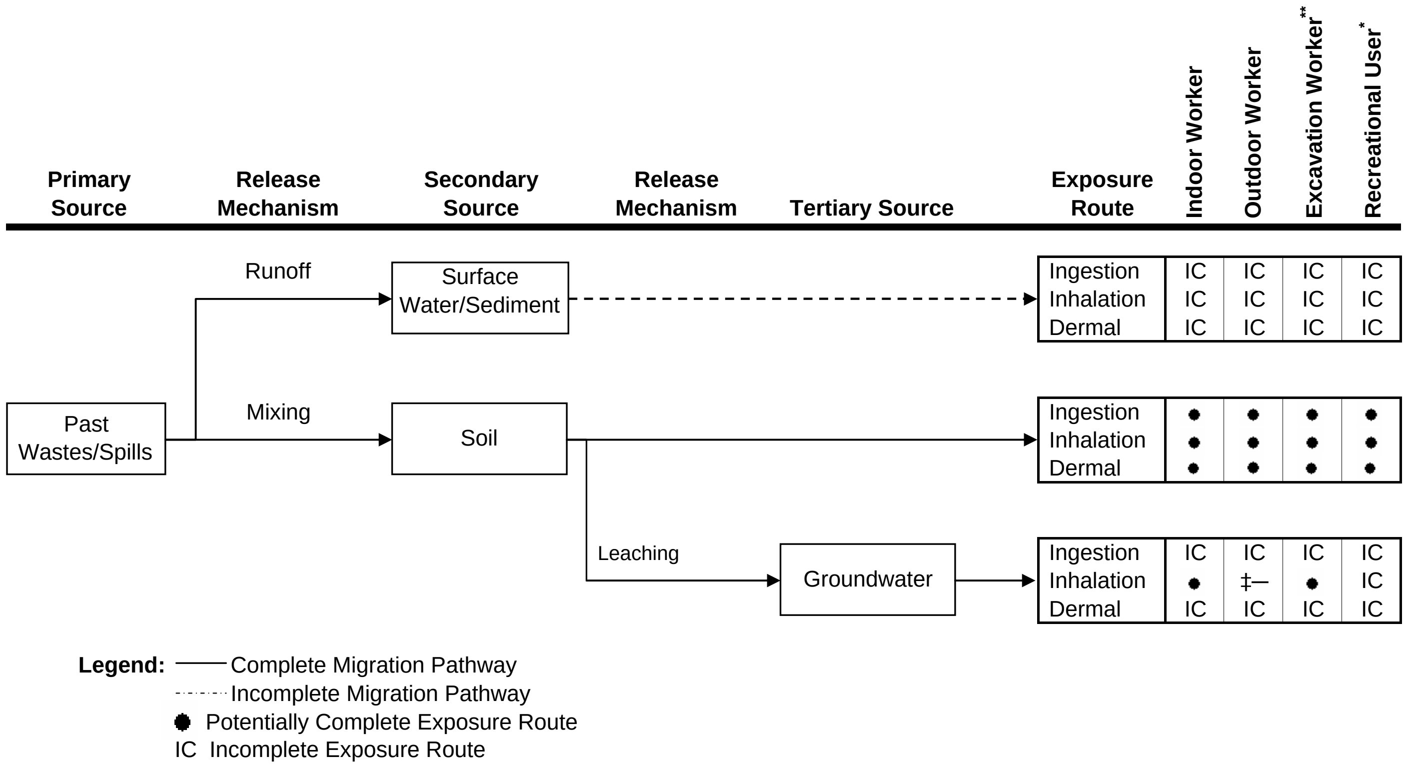
Legend: —— Complete Migration Pathway
-·-·- Incomplete Migration Pathway
● Potentially Complete Exposure Route
IC Incomplete Exposure Route

* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

*** Anglers at Crab Orchard Lake. Site 0069 is located along the shoreline of the Lake.

Figure 7
Site Conceptual Exposure Model
Non-Industrial Sites with Soil Contamination
Sites AUS-0001, AUS-0018, AUS-0060, AUS-0061, AUS-0065, AUS-0067, and AUS-106A
AUS-OU
Crab Orchard National Wildlife Refuge
Marion, Illinois



* "Recreational Use" refers to a wide range of potential receptor populations (birders, visitors to an education center, hunters, anglers, etc.). While the exposure frequency, exposure areas, etc. are likely to vary for each of these populations, the types of exposure are likely to be similar. See text for a more detailed description of potentially exposed populations.

** "Excavation Worker" is intended to reflect any individuals who might be exposed to subsurface soils (construction workers, farmers, tree planters, etc.)

APPENDIX A

Summary of Typical Environmental Education Sites at National Wildlife Refuges

Patuxent Research Refuge, Patuxent MD

- Established in 1936
- Original 2,670 acre refuge to its present size of 12,750 acres
- Encompasses land formerly managed by the Departments of Agriculture and Defense
- The National Wildlife Visitor Center, located on the refuge, is one of the largest science and environmental education sites operated by the U.S. Department of the Interior. The facility is designed to accommodate one million visitors per year. The ~40,000 ft2 (~0.85 acre) main building consists of a lobby, several exhibit and conference rooms and a 218 person auditorium.
- The Visitor Center also has a nearby wildlife management demonstration area and outdoor education site for school classes. This pavilion accommodates 40-50 people.
- Two smaller buildings separate of the main building are also used for group environmental education.
- The Visitor Center is open daily (except Christmas) from 10:00 am. - 5:30 pm.

Big Branch NWR, LaCombe, LA

- Established 1994
- 12,000 acre refuge, acquiring land to a total of 22,000 acres
- Outdoor environmental education pavilion that accommodates ~50 people
- Short trails leading from pavilion
- ~3/4 acre in size for entire use area

Neal Smith NWR

- Established in 1991
- 5,065 acre refuge
- Planning to expand to 8,600 acres
- Prairie Learning Center opened in 1997: 13,000 square foot (~0.3 acres) building, 1000 ft. trail to 3-5 acre prairie planting area (groups of kids visit daily to plant harvested prairie seeds
- 200,000 visitors annually

John Heinz NWR, Pennsylvania

- Established 1972
- Environmental education site accommodates over 6000 students/year
- No physical outdoor education facilities, but classes visit accessible locations outdoors and/or near streams to nature watch or take soil or water samples

Bayou Sauvage NWR, New Orleans, LA

- Established 1986
- 18,300 acre refuge
- Outdoor environmental education pavilion with 8 picnic tables (accommodates ~50 people)
- ~1/3 mile trail leading from pavilion to swamp area that is used with every education program
- 1/4 acre field adjacent to pavilion is used for education programs
- Van transportation to smaller disjunct locations for biological sampling education programs

RAGS D

TABLE 0

SITE RISK ASSESSMENT IDENTIFICATION INFORMATION

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Site Name/OU:	Crab Orchard National Wildlife Refuge NPL Site/Additional and Uncharacterized Sites Operable Unit (AUS OU)
Region:	USEPA Region 5
EPA ID Number:	IL8143609487
State:	Illinois
Status:	PRP-led investigation
Federal Facility (Y/N):	Y
EPA Project Manager:	Nanjunda Gowda
EPA Risk Assessor:	Andrew Podowski
Prepared by (Organization):	URS Corporation
Prepared for (Organization):	U.S. Fish & Wildlife Service
Document Title:	Technical Memorandum of the Baseline Human Health Risk Assessment Technical Approach for the Additiional and Uncharacterized Sites Operable Unit, Crab Orchard National Wildlife Refuge NPL Site, Marion, Illinois
Document Date:	April 2006
Probabilistic Risk Assessment (Y/N):	N
Comments:	

RAGS D

TABLE 1.1

SELECTION OF EXPOSURE PATHWAYS

Active Industrial Sites with Soil and Surface Water/Sediment Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Sites 2B, 2D, 2F, 2P, 4 East and 8 South

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
			Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

RAGS D

TABLE 1.2

SELECTION OF EXPOSURE PATHWAYS

Active Industrial Sites with Soil and Surface Water/Sediment Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Site 7

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
			Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Fish Tissue	Contaminants in surface water could be transferred to fish, which could be consumed	Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Fish Tissue	Contaminants in sediment could be transferred to fish, which could be consumed	Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

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TABLE 1.3

SELECTION OF EXPOSURE PATHWAYS

Active Industrial Sites with Soil Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Sites 2R, 4 West, 6, 9, and 13

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
			Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings or excavations	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

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TABLE 1.4

SELECTION OF EXPOSURE PATHWAYS

Non-Industrial Sites with Soil and Surface Water/Sediment Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Sites 10, 11A, 11H, 11N, 11P, 11S, 12, AUS-0002, AUS-0043, AUS-0062, and AUS-0066

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

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TABLE 1.5

SELECTION OF EXPOSURE PATHWAYS

Non-Industrial Sites with Soil and Surface Water/Sediment Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Site 0069

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Surface Water	Surface Water	Direct contact with contaminated surface water	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Fish Tissue	Contaminants in surface water could be transferred to fish, which could be consumed	Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
	Sediment	Sediment	Direct contact with contaminated sediment	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Fish Tissue	Contaminants in sediment could be transferred to fish, which could be consumed	Anglers	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

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TABLE 1.6

SELECTION OF EXPOSURE PATHWAYS

Non-Industrial Sites with Soil Contamination

Crab Orchard National Wildlife Refuge, Marion, Illinois

AUS Operable Unit

Sites AUS-0001, AUS-0018, AUS-0060, AUS-0061, AUS-0065, AUS-0067, and AUS-106A

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface Soil	Direct contact with contaminated soil	Outdoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Outdoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
				Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying buildings	Indoor Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
Current/Future	Soil	Surface Soil	Direct contact with contaminated soil	Recreational Users	Adult + Child	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from surface soil	Recreational Users	Adult + Child	Inhalation	quantitative	Potentially complete exposure pathway
		Combined Surface and Subsurface Soil	Direct contact with contaminated soil	Excavation Workers	Adult	Ingestion	quantitative	Potentially complete exposure pathway
						Dermal Contact	quantitative	Potentially complete exposure pathway
		Air	Dust generated from combined surface and subsurface soil	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
			Vapors released from underlying soil into excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway
	Groundwater	Air	Vapors released from groundwater into overlying excavations	Excavation Workers	Adult	Inhalation	quantitative	Potentially complete exposure pathway

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TABLE 4.1 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1991a	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1993	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Recreational User	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRaS	Ingestion Rate of Soil - Adult	50	mg/day	USEPA, 1993	
				IRcS	Ingestion Rate of Soil - Child	100	mg/day	USEPA, 2002e	$\frac{CS x EF x CF1 x \left(\frac{IRcS x EDc}{BWc} + \frac{IRaS x EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

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TABLE 4.1 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRaS	Ingestion Rate of Soil - Adult	50	mg/day	USEPA, 1993	$\frac{CS x EF x CF1 x \left(\frac{IRcS x EDc}{BWc} + \frac{IRaS x EDa}{BWa} \right)}{AT}$
				IRcS	Ingestion Rate of Soil - Child	100	mg/day	USEPA, 2002e	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	
Dermal	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	

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TABLE 4.1 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Recreational User	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	3,160	cm^2	USEPA, 1997a	
				SSAFa	Soil to Skin Adherence Factor - Adult	0.04	mg/cm^2	USEPA, 2004b	$\frac{CSxDABSxEFxCF1x\left(\frac{SAcxSSAFcxEDc}{BWc}+\frac{SAaxSSAFaxEDa}{BWa}\right)}{AT}$
				SAc	Skin Surface Area available for contact - Child	1,910	cm^2	USEPA, 1997a	
				SSAFc	Soil to Skin Adherence Factor - Child	0.04	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1991a	
	Angler	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	3,160	cm^2	USEPA, 1997a	
				SSAFa	Soil to Skin Adherence Factor - Adult	0.04	mg/cm^2	USEPA, 2004b	$\frac{CSxDABSxEFxCF1x\left(\frac{SAcxSSAFcxEDc}{BWc}+\frac{SAaxSSAFaxEDa}{BWa}\right)}{AT}$
				SAc	Skin Surface Area available for contact - Child	1,910	cm^2	USEPA, 1997a	
				SSAFc	Soil to Skin Adherence Factor - Child	0.04	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.2 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Combined surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Excavation Worker	Adult	Contaminated soil	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]
Dermal	Excavation Worker	Adult	Contaminated soil	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]

[a] Not Evaluated. USEPA considers an excavation scenario an upperbound exposure scenario, and does not recommend evaluating CT for this scenario.

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TABLE 4.3 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Dust and Vapors from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	VOC release from underlying soils into a building will be evaluated using the Johnson & Ettinger model (USEPA, 2002b)
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Outdoor Worker	Adult	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Excavation Worker	Adult	Dust and Vapors from contaminated soil	NE[d]	NE[d]	NE[d]	NE[d]	NE[d]	NE[d]
	Recreational User	Adult + Child	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	$\frac{CS\ x\,(1/PEF)\ x\ IN\ x\ EF\ x\left(\frac{EDc}{BWc}+\frac{EDa}{BWa}\right)}{AT}$
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

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TABLE 4.3 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Angler	Adult + Child	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	$\frac{CS \ x \ (1/PEF) \ x \ IN \ x \ EF \ x \left(\frac{EDc}{BWc} + \frac{EDa}{BWa}\right)}{AT}$
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Particulate Emission Factors and Volatilization Factors will be calculated based on site-specific conditions using the equations provided in USEPA 2002d.

[c] Not Applicable. Per section 4.4.3 of the HHRA Technical Memorandum, non-cancer Hazard Quotients will be evaluated by comparing air concentrations to the appropriate Reference Concentrations (RfC values).

[d] Not Evaluated. USEPA considers an excavation scenario an upperbound exposure scenario, and does not recommend evaluating CT for this scenario.

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TABLE 4.4 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.017	L/day	USEPA, 1997a	*(CW x IRW x EF x ED)/(BW x AT)*
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Recreational User	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.017	L/day	USEPA, 1997a, 2002e	$\frac{CW \ x\ EF \ x\ IRW \left(\frac{EDc}{BWc}+\frac{EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	
	Angler	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.017	L/day	USEPA, 1997a, 2002e	$\frac{CW \ x\ EF \ x\ IRW \left(\frac{EDc}{BWc}+\frac{EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

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TABLE 4.4 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CW x SA x KP x ET x EF x ED x CF2)/(BW x AT)*
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	1	hours/day	site-specific[b]	
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF2	Conversion Factor	0.001	L/cm^3		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Recreational User	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	$\frac{CW\,x\,KPx\,ET\,x\,EF\,x\,CF2\,x\left(\frac{SAc\,x\,EDc}{BWc}+\frac{SAa\,x\,EDa}{BWa}\right)}{AT}$
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	1	hours/day	site-specific[b]	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

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TABLE 4.4 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Angler	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	$\frac{CW\ x\ KP\ x\ ET\ x\ EF\ x\ CF2\ x\left(\frac{SAc\ x\ EDc}{BWc}+\frac{SAa\ x\ EDa}{BWa}\right)}{AT}$
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	1	hours/day	site-specific[b]	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.5 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Fish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated fish	CF	Chemical concentration in fish	See Table 3[a,b]	mg/kg	See Table 3[a,b]	*CDI (mg/kg/day) =* $\frac{CF\,x\,EF\,x\left(\frac{IRFc\,x\,EDc}{BWc}+\frac{IRFa\,x\,EDa}{BWa}\right)}{AT}$
				IRFa	Ingestion Rate of Fish - Adult	0.008	kg/day	USEPA, 1997a	
				IRFc	Ingestion Rate of Fish - Child	0.00188	kg/day	USEPA, 2002e	
				EF	Exposure Frequency	365	days/year	USEPA, 1997a	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Fish tissues are not being collected during the current phase of investigation. The decision as to whether fish data are required will be made based on screening of surface water and sediment data.

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TABLE 4.6 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSD	Ingestion Rate of Sediment	50	mg/day	USEPA, 1993	*(CSD x IRSD x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Recreational User	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSDa	Ingestion Rate of Sediment - Adult	50	mg/day	USEPA, 1993	$\frac{CSD\,x\,EF\,x\,CF1\,x\left(\frac{IRSDc\,x\,EDc}{BWc}+\frac{IRSDa\,x\,EDa}{BWa}\right)}{AT}$
				IRSDc	Ingestion Rate of Sediment - Child	100	mg/day	USEPA, 2002e	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	
	Angler	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSDa	Ingestion Rate of Sediment - Adult	50	mg/day	USEPA, 1993	
				IRSDc	Ingestion Rate of Sediment - Child	100	mg/day	USEPA, 2002e	
				EF	Exposure Frequency	26	days/year	site-specific[b]	$\frac{CSD\,x\,EF\,x\,CF1\,x\left(\frac{IRSDc\,x\,EDc}{BWc}+\frac{IRSDa\,x\,EDa}{BWa}\right)}{AT}$
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

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TABLE 4.6 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CSD x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Recreational User	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	$\frac{CSD x DABS x EF x CF1 x \left(\frac{SAc x SSAFc x EDc}{BWc} + \frac{SAa x SSAFa x EDa}{BWa}\right)}{AT}$
				SSAFa	Sediment to Skin Adherence Factor - Adult	0.04	mg/cm^2	USEPA, 2004b	
				SSAFc	Sediment to Skin Adherence Factor - Child	0.04	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

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TABLE 4.6 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Angler	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	$\frac{CSD \times DABS \times EF \times CF \times \left(\frac{SAc \times SSAFc \times EDc}{BWc} + \frac{SAa \times SSAFa \times EDa}{BWa}\right)}{AT}$
				SSAFa	Sediment to Skin Adherence Factor - Adult	0.04	mg/cm^2	USEPA, 2004b	
				SSAFc	Sediment to Skin Adherence Factor - Child	0.04	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.7 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Fish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated fish	CF	Chemical concentration in fish	See Table 3[a,b]	mg/kg	See Table 3[a,b]	*CDI (mg/kg/day) =*
				IRFa	Ingestion Rate of Fish - Adult	0.008	kg/day	USEPA, 1997a	
				IRFc	Ingestion Rate of Fish - Child	0.00188	kg/day	USEPA, 2002e	$\frac{CF\ x\ EF x \left(\frac{IRFc\ x\ EDc}{BWc} + \frac{IRFa + EDa}{BWa} \right)}{AT}$
				EF	Exposure Frequency	365	days/year	USEPA, 1997a	
				EDa	Exposure Duration - Adult	3	years	USEPA, 1997a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1997a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	3,285	days	USEPA, 1997a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Fish tissues are not being collected during the current phase of investigation. The decision as to whether fish data are required will be made based on screening of surface water and sediment data.

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TABLE 4.8 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Air in building	(1)	(1)	(1)	(1)	USEPA, 2002b	Johnson & Ettinger model
	Excavation Worker	Adult	Air in excavation	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]	NE[a]

(1) Vapor Intrusion cancer risks and hazard quotients will be evaluated using the Johnson & Ettinger model, per USEPA (2002b).

[a] Not Evaluated. USEPA considers an excavation scenario an upperbound exposure scenario, and does not recommend evaluating CT for this scenario.

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TABLE 4.9 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1991a	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1993	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
Dermal	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	

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TABLE 4.9 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	

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TABLE 4.10 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Dust and vapors from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	VOC release from underlying soils into a building will be evaluated using the Johnson & Ettinger model (USEPA, 2002b)
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Outdoor Worker	Adult	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	219	days/year	USEPA, 2004b	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Particulate Emission Factors and Volatilization Factors will be calculated based on site-specific conditions using the equations provided in USEPA 2002d.

[c] Not Applicable. Per section 4.4.3 of the HHRA Technical Memorandum, non-cancer Hazard Quotients will be evaluated by comparing air concentrations to the appropriate Reference Concentrations (RfC values).

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TABLE 4.11 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.017	L/day	USEPA, 1997a	*(CW x IRW x EF x ED)/(BW x AT)*
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
Dermal	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CW x SA x KP x ET x EF x ED x CF2)/(BW x AT)*
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	1	hours/day	site-specific[b]	
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF2	Conversion Factor	0.001	L/cm^3		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.12 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSD	Ingestion Rate of Sediment	50	mg/day	USEPA, 1993	*(CSD x IRSD x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	
Dermal	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CSD x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	13	days/year	site-specific[b]	
				ED	Exposure Duration	5	years	US Dept Labor, 1987	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	1,825	days	US Dept Labor, 1987	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.13 CT

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Air in building	(1)	(1)	(1)	(1)	USEPA, 2002b	Johnson & Ettinger model

(1) Vapor Intrusion cancer risks and hazard quotients will be evaluated using the Johnson & Ettinger model, per USEPA (2002b).

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TABLE 4.1 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1991a	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRS	Ingestion Rate of Soil	100	mg/day	USEPA, 1993	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Recreational User	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRaS	Ingestion Rate of Soil - Adult	100	mg/day	USEPA, 1991a	
				IRcS	Ingestion Rate of Soil - Child	200	mg/day	USEPA, 1991a	$\frac{CS x EF x CF1 x \left(\frac{IRcS x EDc}{BWc} + \frac{IRaS x EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

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TABLE 4.1 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRaS	Ingestion Rate of Soil - Adult	100	mg/day	USEPA, 1991a	$\frac{CS x EF x CF1 x \left(\frac{IRcS x EDc}{BWc} + \frac{IRaS x EDa}{BWa}\right)}{AT}$
				IRcS	Ingestion Rate of Soil - Child	200	mg/day	USEPA, 1991a	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	
Dermal	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	

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TABLE 4.1 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Recreational User	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =* $\frac{CS x DABS x EF x CF1 x \left(\frac{SAc x SSAFc x EDc}{BWc} + \frac{SAa x SSAFa x EDa}{BWa}\right)}{AT}$
				SAa	Skin Surface Area available for contact - Adult	3,160	cm^2	USEPA, 1997a	
				SSAFa	Soil to Skin Adherence Factor - Adult	0.3	mg/cm^2	USEPA, 2004b	
				SAc	Skin Surface Area available for contact - Child	1,910	cm^2	USEPA, 1997a	
				SSAFc	Soil to Skin Adherence Factor - Child	0.4	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	
	Angler	Adult + Child	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =* $\frac{CS x DABS x EF x CF1 x \left(\frac{SAc x SSAFc x EDc}{BWc} + \frac{SAa x SSAFa x EDa}{BWa}\right)}{AT}$
				SAa	Skin Surface Area available for contact - Adult	3,160	cm^2	USEPA, 1997a	
				SSAFa	Soil to Skin Adherence Factor - Adult	0.3	mg/cm^2	USEPA, 2004b	
				SAc	Skin Surface Area available for contact - Child	1,910	cm^2	USEPA, 1997a	
				SSAFc	Soil to Skin Adherence Factor - Child	0.4	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.2 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Excavation Worker	Adult	Contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				IRS	Ingestion Rate of Soil	330	mg/day	USEPA, 2001a	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	1	years	USEPA, 2002e	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	365	days	USEPA, 2002e	
Dermal	Excavation Worker	Adult	Contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2	USEPA, 2004b	
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	1	years	USEPA, 2002e	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	365	days	USEPA, 2002e	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

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TABLE 4.3 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Dust and Vapors from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	VOC release from underlying soils into a building will be evaluated using the Johnson & Ettinger model (USEPA, 2002b)
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Outdoor Worker	Adult	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Excavation Worker	Adult	Dust and Vapors from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (inhalation of dust)(mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				VF	Volatilization Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	*CDI (inhalation of vapors)(mg/kg/day) =*
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	*(CS x (1/VF) x IN x EF x ED)/(BW x AT)*
				ED	Exposure Duration	1	years	USEPA, 2002e	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

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TABLE 4.3 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Adult + Child	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	$\frac{CS\ x\ (1/PEF)\ x\ IN\ x\ EF\ x\ \left(\frac{EDc}{BWc}+\frac{EDa}{BWa}\right)}{AT}$
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Angler	Adult + Child	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	$\frac{CS\ x\ (1/PEF)\ x\ IN\ x\ EF\ x\ \left(\frac{EDc}{BWc}+\frac{EDa}{BWa}\right)}{AT}$
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Particulate Emission Factors and Volatilization Factors will be calculated based on site-specific conditions using the equations provided in USEPA 2002d.

[c] Not Applicable. Per section 4.4.3 of the HHRA Technical Memorandum, non-cancer Hazard Quotients will be evaluated by comparing air concentrations to the appropriate Reference Concentrations (RfC values).

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TABLE 4.4 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.05	L/day	USEPA, 1989	*(CW x IRW x EF x ED)/(BW x AT)*
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Recreational User	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.05	L/day	USEPA, 1989	$\frac{CW \ x \ EF \ x \ IRW \left(\frac{EDc}{BWc} + \frac{EDa}{BWa} \right)}{AT}$
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	
	Angler	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.05	L/day	USEPA, 1989	$\frac{CW \ x \ EF \ x \ IRW \left(\frac{EDc}{BWc} + \frac{EDa}{BWa} \right)}{AT}$
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

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TABLE 4.4 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CW x SA x KP x ET x EF x ED x CF2)/(BW x AT)*
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	2	hours/day	site-specific[b]	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Recreational User	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	$\frac{CW\,x\,KP\,x\,ET\,x\,EF\,x\,CF2\,x\left(\frac{SAc\,x\,EDc}{BWc}+\frac{SAa\,x\,EDa}{BWa}\right)}{AT}$
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	2	hours/day	site-specific[b]	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

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TABLE 4.4 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Angler	Adult + Child	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	$\frac{CW\,x\,KP\,x\,ET\,x\,EF\,x\,CF2\,x\left(\frac{SAc\,x\,EDc}{BWc}+\frac{SAa\,x\,EDa}{BWa}\right)}{AT}$
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	2	hours/day	site-specific[b]	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.5 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Fish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated fish	CF	Chemical concentration in fish	See Table 3[a,b]	mg/kg	See Table 3[a,b]	*CDI (mg/kg/day) =*
				IRFa	Ingestion Rate of Fish - Adult	0.025	kg/day	USEPA, 1997a	$\frac{CF x EF x \left(\frac{IRFc x EDc}{BWc} + \frac{IRFa x EDa}{BWa} \right)}{AT}$
				IRFc	Ingestion Rate of Fish - Child	0.0139	kg/day	USEPA, 2002e	
				EF	Exposure Frequency	365	days/year	USEPA, 1997a	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Fish tissues are not being collected during the current phase of investigation. The decision as to whether fish data are required will be made based on screening of surface water and sediment data.

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TABLE 4.6 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSD	Ingestion Rate of Sediment	100	mg/day	USEPA, 1993	*(CSD x IRSD x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Recreational User	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSDa	Ingestion Rate of Sediment - Adult	100	mg/day	USEPA, 1991a	$\frac{CSD\,x\,EF\,x\,CF1\,x\left(\frac{IRSDc\,x\,EDc}{BWc}+\frac{IRSDa\,x\,EDa}{BWa}\right)}{AT}$
				IRSDc	Ingestion Rate of Sediment - Child	200	mg/day	USEPA, 1991a	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	
	Angler	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSDa	Ingestion Rate of Sediment - Adult	100	mg/day	USEPA, 1991a	
				IRSDc	Ingestion Rate of Sediment - Child	200	mg/day	USEPA, 1991a	$\frac{CSD\,x\,EF\,x\,CF1\,x\left(\frac{IRSDc\,x\,EDc}{BWc}+\frac{IRSDa\,x\,EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

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TABLE 4.6 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CSD x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Recreational User	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	$\frac{CSD x DABS x EF x CF1 x \left(\frac{SAc x SSAFc x EDc}{BWc} + \frac{SAa x SSAFa x EDa}{BWa}\right)}{AT}$
				SSAFa	Sediment to Skin Adherence Factor - Adult	0.3	mg/cm^2	USEPA, 2004b	
				SSAFc	Sediment to Skin Adherence Factor - Child	0.4	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

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TABLE 4.6 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Angler	Adult + Child	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SAa	Skin Surface Area available for contact - Adult	6,350	cm^2	USEPA, 1997a	
				SAc	Skin Surface Area available for contact - Child	3,122	cm^2	USEPA, 1997a	$\frac{CSD \times DABS \times EF \times CF \times \left(\frac{SAc \times SSAFc \times EDc}{BWc} + \frac{SAa \times SSAFa \times EDa}{BWa}\right)}{AT}$
				SSAFa	Sediment to Skin Adherence Factor - Adult	0.3	mg/cm^2	USEPA, 2004b	
				SSAFc	Sediment to Skin Adherence Factor - Child	0.4	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	52	days/year	site-specific[b]	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.7 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Fish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult + Child	Contaminated fish	CF	Chemical concentration in fish	See Table 3[a,b]	mg/kg	See Table 3[a,b]	*CDI (mg/kg/day) =*
				IRFa	Ingestion Rate of Fish - Adult	0.025	kg/day	USEPA, 1997a	
				IRFc	Ingestion Rate of Fish - Child	0.0139	kg/day	USEPA, 2002e	$\frac{CF\ x\ EF x\left(\frac{IRFc x\ EDc}{BWc}+\frac{IRFa + EDa}{BWa}\right)}{AT}$
				EF	Exposure Frequency	365	days/year	USEPA, 1997a	
				EDa	Exposure Duration - Adult	24	years	USEPA, 1991a	
				EDc	Exposure Duration - Child	6	years	USEPA, 1991a	
				BWa	Body Weight - Adult	70	kg	USEPA, 1991a	
				BWc	Body Weight - Child	15	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	10,950	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Fish tissues are not being collected during the current phase of investigation. The decision as to whether fish data are required will be made based on screening of surface water and sediment data.

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TABLE 4.8 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Air in building	(1)	(1)	(1)	(1)	USEPA, 2002b	Johnson & Ettinger model
	Excavation Worker	Adult	Air in excavation	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	
				VF	Volatilization Factor	Site-specific[b]	L/m^3	USEPA, 1999	
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	*CDI (inhalation of vapors)(mg/kg/day) =*
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	*(CW x (1/VF) x IN x EF x ED)/(BW x AT)*
				ED	Exposure Duration	1	years	USEPA, 2002e	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

(1) Vapor Intrusion cancer risks and hazard quotients will be evaluated using the Johnson & Ettinger model, per USEPA (2002b).

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.9 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				IRS	Ingestion Rate of Soil	50	mg/day	USEPA, 1991a	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRS	Ingestion Rate of Soil	100	mg/day	USEPA, 1993	*(CS x IRS x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
Dermal	Indoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	

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TABLE 4.9 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Outdoor Worker	Adult	Contaminated surface soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	3,160	cm^2	USEPA, 1997a	*(CS x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	

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TABLE 4.10 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Dust and vapors from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*Chronic Daily Intake (CDI) (mg/kg/day)=*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	250	days/year	USEPA, 2002d	VOC release from underlying soils into a building wil be evaluated using the Johnson & Ettinger model (USEPA, 2002b)
				ED	Exposure Duration	25	years	USEPA, 1991a	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			
	Outdoor Worker	Adult	Dust from contaminated soil	CS	Chemical concentration in soil	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				PEF	Particulate Emission Factor	Site-specific[b]	m^3/kg	USEPA, 2002d	*(CS x (1/PEF) x IN x EF x ED)/(BW x AT)*
				IN	Inhalation Rate	20	m^3/day	USEPA, 2002d	
				EF	Exposure Frequency	225	days/year	USEPA, 2002d	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	NA[c]			

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Particulate Emission Factors and Volatilization Factors will be calculated based on site-specific conditions using the equations provided in USEPA 2002d.

[c] Not Applicable. Per section 4.4.3 of the HHRA Technical Memorandum, non-cancer Hazard Quotients will be evaluated by comparing air concentrations to the appropriate Reference Concentrations (RfC values).

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TABLE 4.11 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				IRW	Ingestion Rate of Water	0.05	L/day	USEPA, 1989	*(CW x IRW x EF x ED)/(BW x AT)*
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
Dermal	Outdoor Worker	Adult	Contaminated surface water	CW	Chemical concentration in water	See Table 3[a]	mg/L	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CW x SA x KP x ET x EF x ED x CF2)/(BW x AT)*
				KP	Permeability Constant	Chemical-specific	cm/hour	USEPA, 2004b	
				ET	Exposure Time	2	hours/day	site-specific[b]	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF2	Conversion Factor	0.001	L/cm^3		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.12 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				IRSD	Ingestion Rate of Sediment	100	mg/day	USEPA, 1993	*(CSD x IRSD x EF x ED x CF1)/(BW x AT)*
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	
Dermal	Outdoor Worker	Adult	Contaminated sediment	CSD	Chemical concentration in sediment	See Table 3[a]	mg/kg	See Table 3[a]	*CDI (mg/kg/day) =*
				SA	Skin Surface Area available for contact	6,350	cm^2	USEPA, 1997a	*(CSD x SA x SSAF x DABS x EF x ED x CF1)/(BW x AT)*
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA, 2004b	
				DABS	Dermal Absorption Factor - Solid	Chemical-specific	-	USEPA, 2004b	
				EF	Exposure Frequency	26	days/year	site-specific[b]	
				ED	Exposure Duration	25	years	USEPA, 1991a	
				CF1	Conversion Factor 1	1.00E-06	kg/mg		
				BW	Body Weight	70	kg	USEPA, 1991a	
				AT-C	Averaging Time - Cancer	25,550	days	USEPA, 1991a	
				AT-NC	Averaging Time - Non-cancer	9,125	days	USEPA, 1991a	

[a] Exposure Point Concentrations will be provided in RAGS D Table 3, which is a future deliverable.

[b] Supporting discussion presented in Section 4 of the HHRA Technical Memorandum.

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TABLE 4.13 RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Crab Orchard National Wildlife Refuge, Marion, Illinois

Additional and Uncharacterized Sites Operable Unit (AUS OU)

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Indoor Worker	Adult	Air in building	(1)	(1)	(1)	(1)	USEPA, 2002b	Johnson & Ettinger model

(1) Vapor Intrusion cancer risks and hazard quotients will be evaluated using the Johnson & Ettinger model, per USEPA (2002b).